# Pengantar Menuju Analisis Data Longitudinal '*Sebenarnya*'

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# Terminologi

## Data Longitudinal

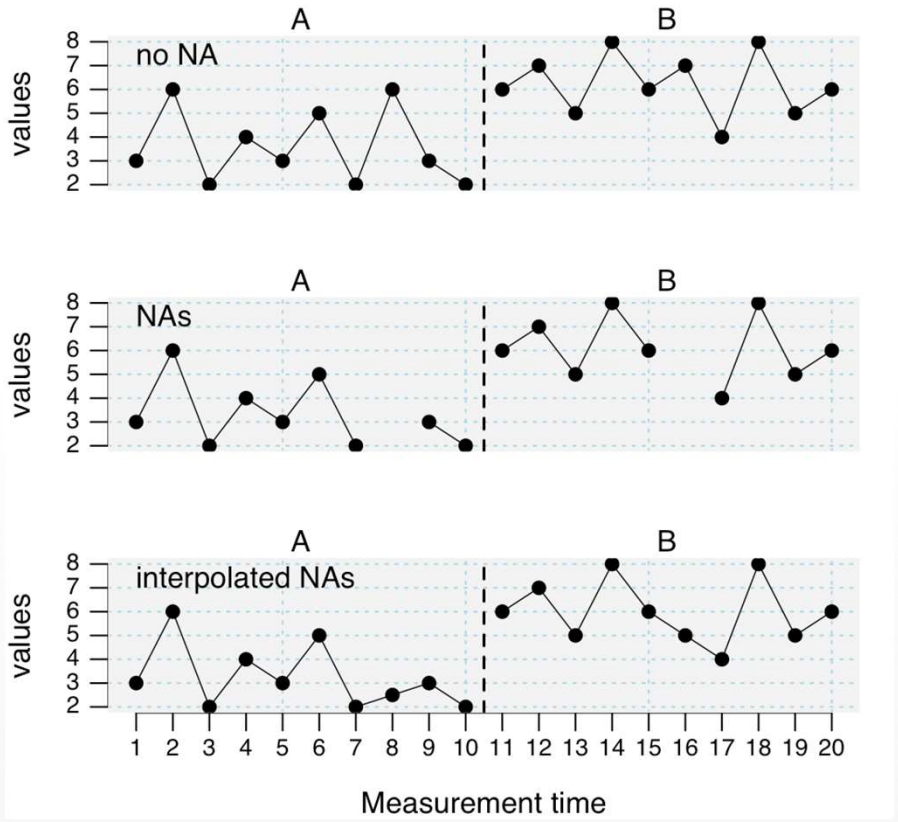
- Data dari beberapa pengamatan berulang (antar waktu) pada suatu unit
  - Unit dapat berupa individu, sekolah, benda dsb.
- Data longitudinal vs Cross sectional data

## Repeated Measures

- Biasanya dipakai dalam penelitian eksperimental dimana subjek mendapatkan perlakuan yang berbeda-beda pada suatu interval waktu
  - Misalnya desain ABBA

# Kelebihan Data Longitudinal

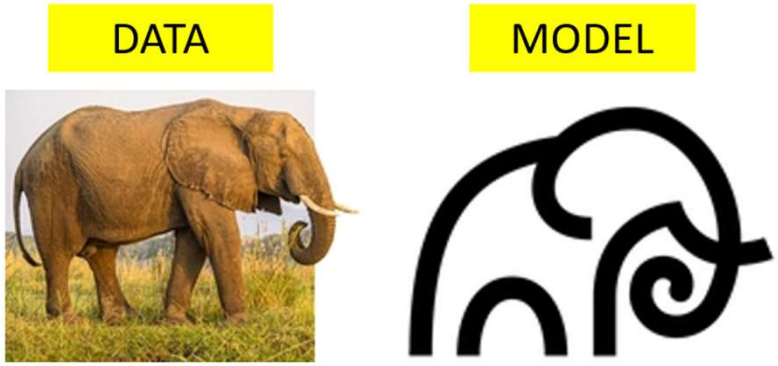
- Memberikan informasi mengenai **pola perubahan**
- Lebih ekonomis, bisa tidak melibatkan banyak partisipan
- Mengurangi **varians eror** terkait dengan perbedaan karakteristik individu



# Fixed vs Random Effect

# Pemodelan dalam Analisis

- Model adalah cara untuk menjelaskan realitas
- Elemen model didasarkan pada teori atau acuan
  - Variabel, parameter, constrain
- Model yang bagus adalah yang sederhana (parsimoni) namun dapat memprediksi kompleksitas (variabilitas) di dalam data
  - daripada model yang kompleks



# Constrained vs Relax

- Demi prinsip parsimoni, model melakukan penetapan (constrained) pada parameternya
- Penetapan/pembekuan ini dilakukan dengan dalam tataran asumsi atau penerapan langsung dalam model
- Penetapan yang dilakukan dalam pemodelan memiliki konsekuensi rendahnya variasi yang tidak diakomodasi oleh model -> berdampak ke *goodness of fit/effect sizes*
  - Model yang 'sakti' tidak takut terhadap hal ini karena tidak berdampak

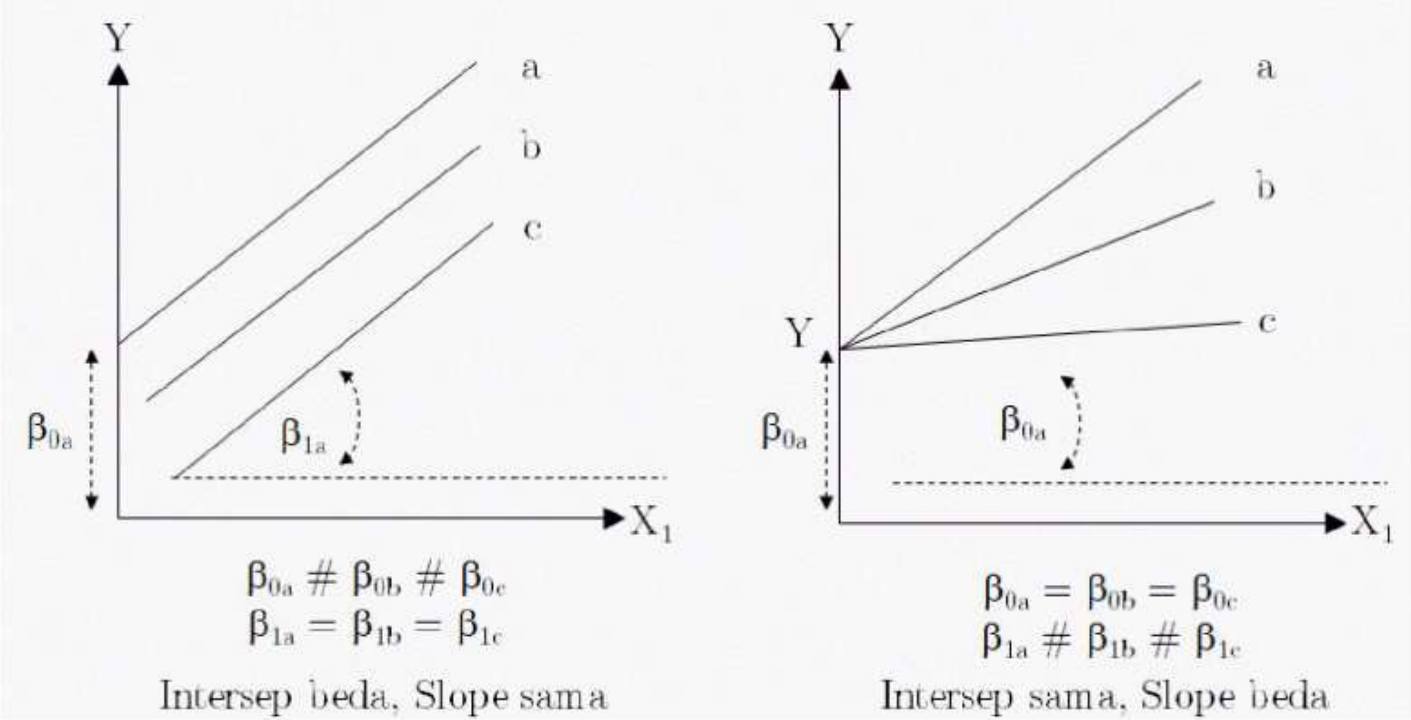
# Contoh Aplikasi Fixed Parameter

- **Teori Tes Klasik**
  - model tes paralel vs model tes congeneric
- **Teori Tes Modern**
  - Rasch Model vs IRT 2 PL
- **SEM/CFA**
  - non residual correlation vs residual correlation
- **Analisis Regresi Multilevel**
  - fixed parameter vs free parameter

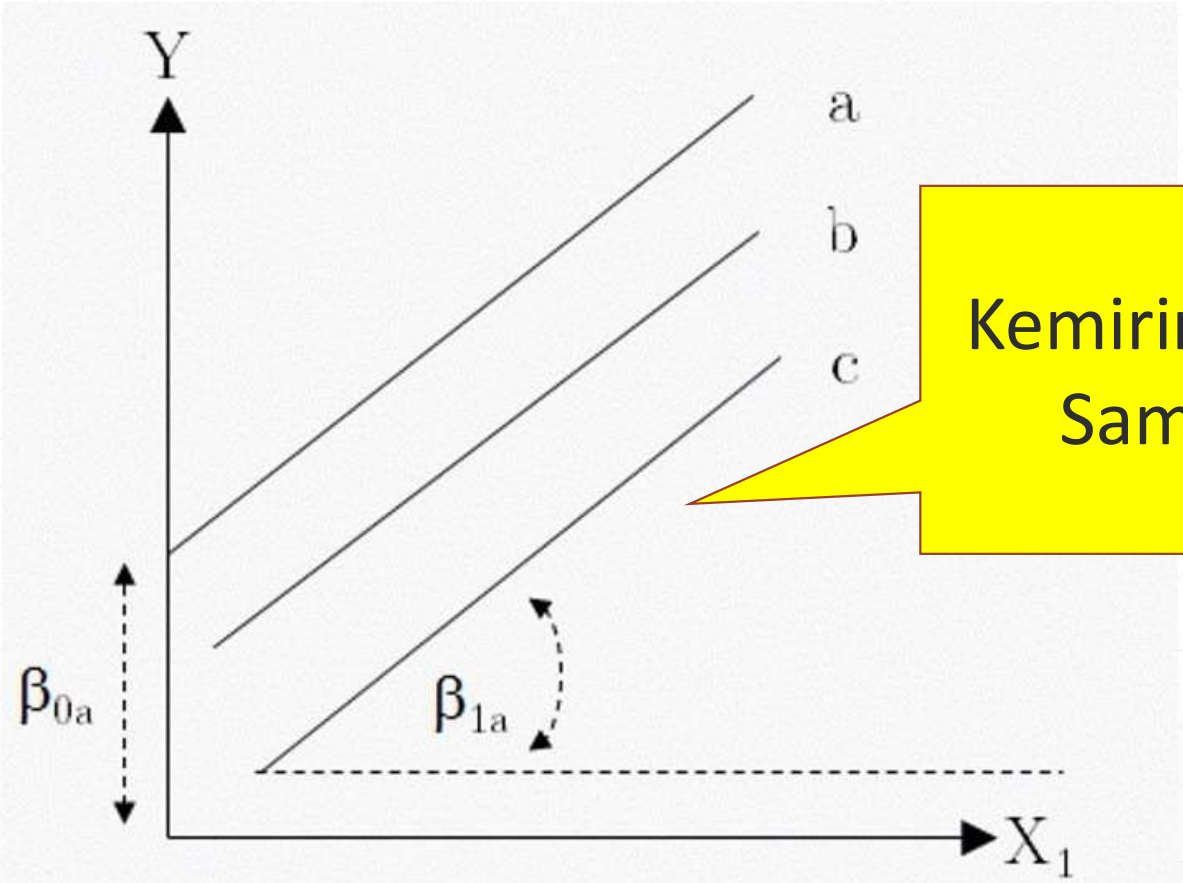
Model dengan pembekuan akan menghasilkan informasi sederhana, bersifat umum dan tidak kondisional (tergantung dari)

# 4 Intersep dan Slope

Kita telah tahu bahwa intersep adalah nilai Y ketika nilai X=0 yang ditunjukkan dengan perpotongan garis regresi dan sumbu Y. Slope menunjukkan kemiringan garis regresi. Gambar 4 menunjukkan garis regresi pada grup atau kelompok individu.




Gambar 4 Model-Model Regresi Multilevel

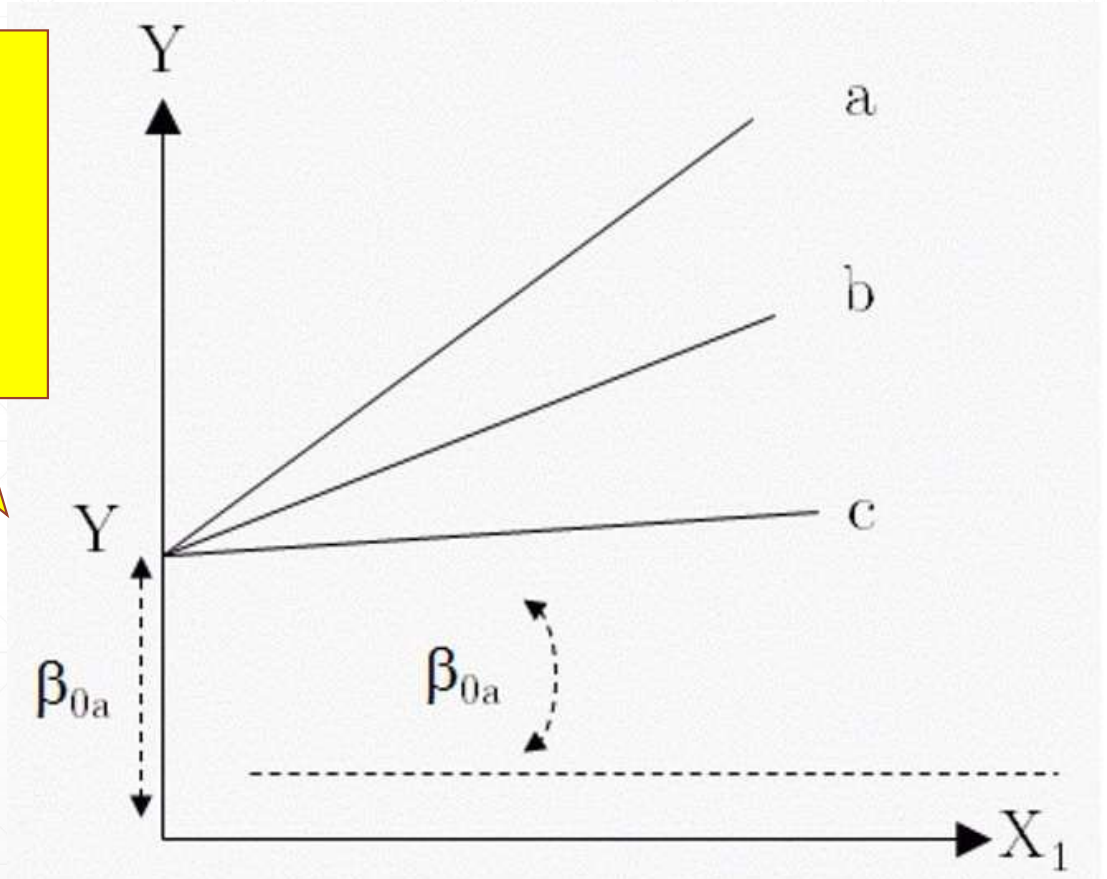



Kemiringan Sama

$$\beta_{0a} \# \beta_{0b} \# \beta_{0c}$$

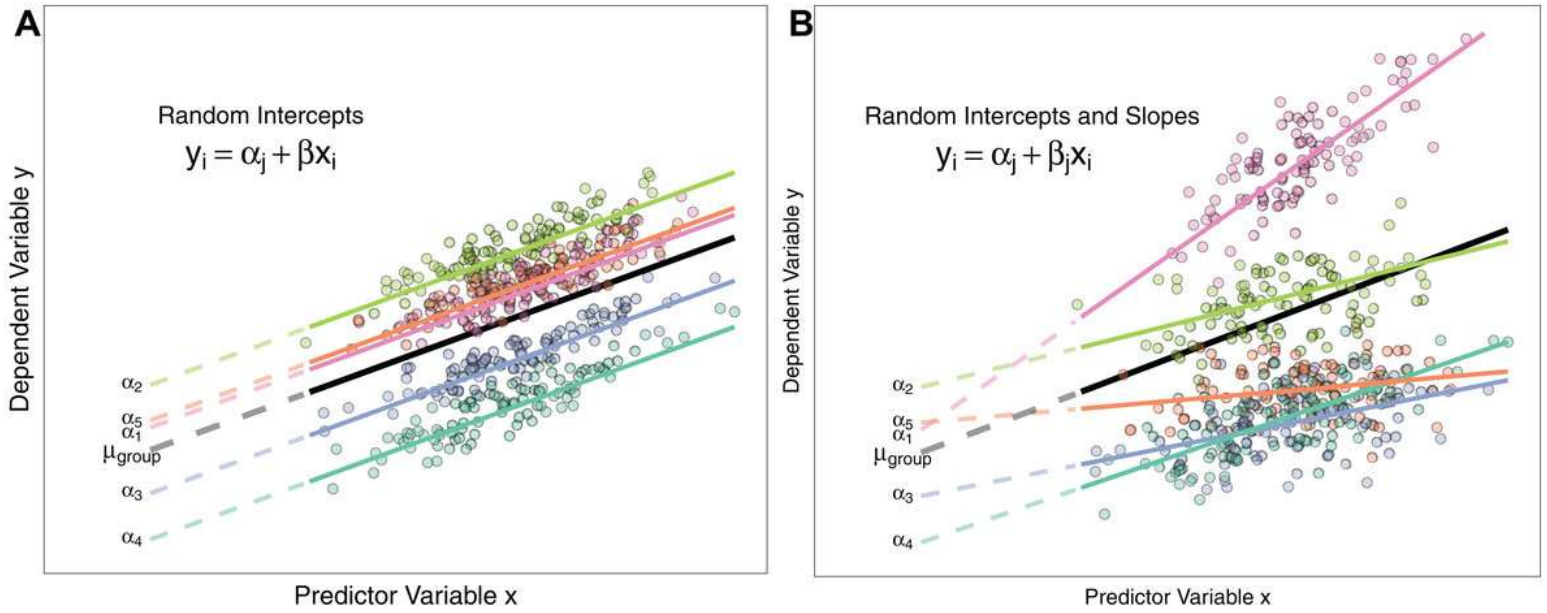
$$\beta_{1a} = \beta_{1b} = \beta_{1c}$$

Intercept Sama




$$\beta_{0a} = \beta_{0b} = \beta_{0c}$$

$$\beta_{1a} \# \beta_{1b} \# \beta_{1c}$$




$$y = \alpha + \beta x_i$$

$$y = \alpha_j + \beta_j x_i$$ Koefisien persamaan dengan dengan parameter random (j)

- Ketika kita terapkan analisis regresi pada kelompok kita akan mendapatkan sejumlah garis regresi yang jumlahnya sama dengan jumlah kelompok. Parameter intersep dan kelompok tersebut bisa saja berbeda.
- Kedua model ini kita terapkan pada data kita.
- Model mana yang paling tepat akan terlihat dari uji kecocokan model yang paling tinggi.
- Persamaan regresi untuk masing-masing model adalah sebagai berikut:

Intersep sama & Slope beda $$Y_{\text{ij}} = \beta_0 + \beta_{1\text{j}}\text{X}_{\text{ij}} + e_{\text{ij}}$$

Intersep beda & Slope sama $$Y_{\text{ij}} = \beta_{0j} + \beta_1\text{X}_{\text{ij}} + e_{\text{ij}}$$

# Sumber Eror dalam Analisis Longitudinal

# Cerita tengan Eror (Residual)

- **Rerata:** sesuatu standar, normal dan menjadi acuan
- **Deviasi:** **s**impangan dari standar
- **Deviasi standar:** rerata deviasi
- **Eror:** deviasi yang terlalu sering muncul
- **Eror standar (residual):** rerata eror pada sebuah data

$$\mathrm{SD} = \sqrt{\frac{\sum |x - \bar{x}|^2}{n}}$$

$$SE = \frac{SD}{\sqrt{N}}$$

## Bagaimana mereduksi eror?

- Tambahkan ukuran sampel
- Alat ukur yang valid dan reliabel
- Sampling secara random
- .....

# Peranan Eror terhadap Uji Statistika

$$t = \frac{\bar{x} - \mu}{s/\sqrt{n}}$$

Tingginya nilai t tergantung dari selisih dan eror

ANOVA

| | Sum of Squares | df | Mean Square | F | p |
|---|---|---|---|---|---|
| Group | 24.67 | 2 | 12.33 | 10.1 | 0.012 |
| Residuals | 7.33 | 6 | 1.22 | | |

Tingginya nilai F tergantung dari perbandingan varians utama dan eror

# Peranan Eror terhadap Uji Statistika

$$r = \frac{\sum(x-\bar{x})(y-\bar{y})}{\sqrt{\sum(x-\bar{x})^2 \sum(y-\bar{y})^2}}$$

Komponen 2

Komponen 1

Tingginya korelasi tergantung dari kebersamaan dibagi dengan keegoisan (eror)

Model Coefficients

| Predictor | Estimate | SE | t | p |
|---|---|---|---|---|
| Intercept | 100.054 | 17.748 | 5.64 | 0.005 |
| Age | −0.631 | 0.406 | −1.55 | 0.195 |

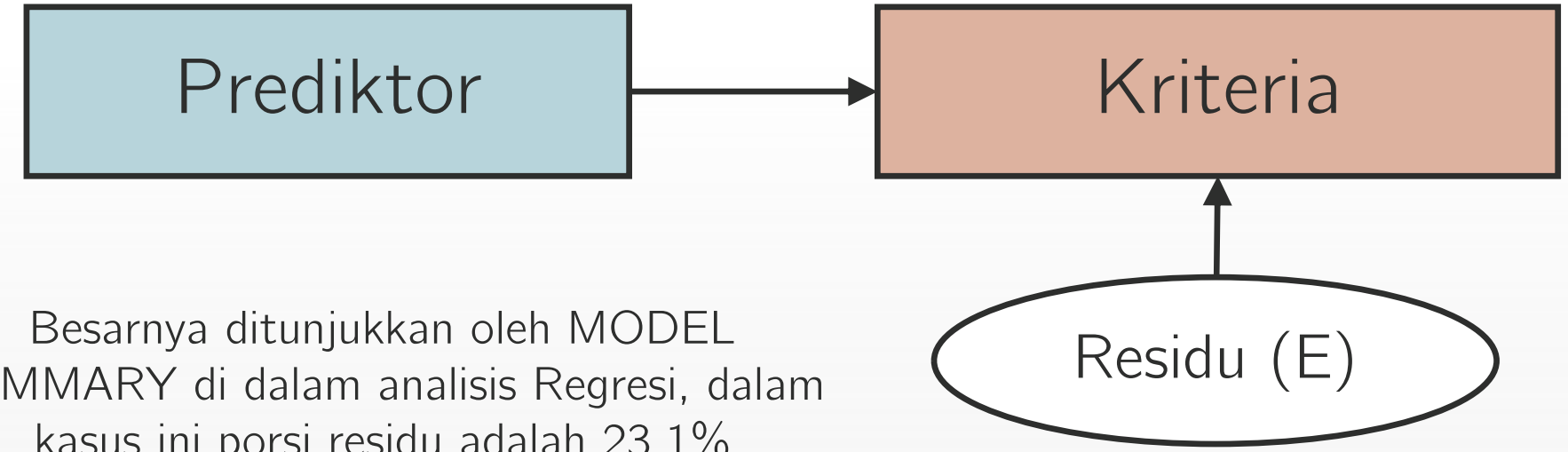
$$t = \frac{B-0}{SE}$$

Signifikannya nilai B tergantung dari prediksi dan eror

# Cerita tentang Residu (*Residual*)

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .877[a] | .769 | .750 | 1.11726 |

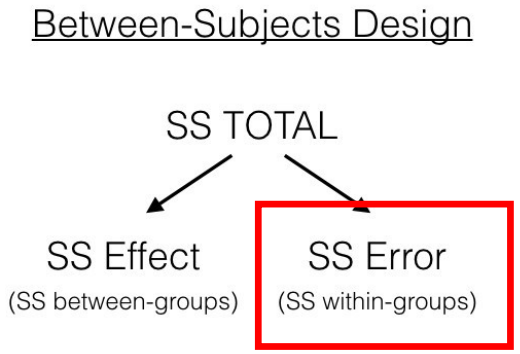
a. Predictors: (Constant), Prediktor

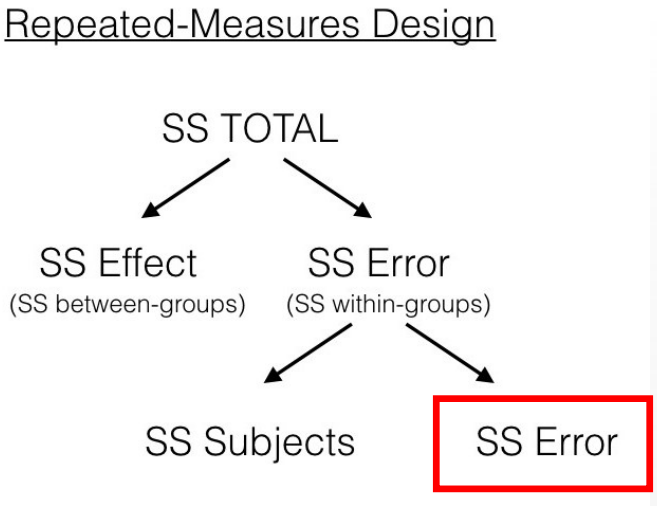



Besarnya ditunjukkan oleh MODEL SUMMARY di dalam analisis Regresi, dalam kasus ini porsi residu adalah 23,1%

# Cerita tentang Residu (*Residual*)

- Pemodelan adalah mengenali variasi (fenomena) di dalam data
- Residu adalah fenomena yang tidak dapat diidentifikasi oleh model dan dilihat sebagai sesuatu yang acak (random)
- Pemodelan dapat mengakomodasi mengakomodasi model ketika ada informasi
  - Anova one way (selain varians kelompok, dianggap sebagai residu)
  - Anova mixed design (selain varians kelompok dan waktu, dianggap sebagai residu)
- Model Kompleks vs Model Parsimoni
- Model fit to data vs Data fit to model



**Varians Dalam Amatan (varians pengganggu)**

Amatan 1 Amatan 2 Amatan 3

**Varians Antar Amatan (varians utama)**

**Varians Dalam Amatan - Varians Antar Amatan = Varians Eror**

**Efek Waktu Terlihat Jelas**
Semua subjek mengalami peningkatan skor dari T1 ke T4, meskipun dengan kecepatan berbeda.

**Perbedaan Laju Perubahan antar Grup**
Grup 1 menunjukkan pertumbuhan lebih cepat dan konsisten, sedangkan Grup 2 lebih lambat dan stabil. Ini bisa mengindikasikan efek perlakuan, intervensi, atau karakteristik grup.

**Potensi Interaksi Waktu × Grup**
Analisis model linear mixed atau ANOVA repeated measures, akan muncul interaksi signifikan antara waktu dan grup, karena pola pertumbuhan antar grup berbeda.

**Kesesuaian untuk Model Longitudinal**
- Model pertumbuhan (growth curve)
- Mixed-effects model dengan random intercept
- Analisis tren antar grup

| Subjek | Grup | T1 | T2 | T3 | T4 |
|---|---|---|---|---|---|
| 1 | 1 | 1 | 2 | 3 | 4 |
| 2 | 1 | 2 | 3 | 4 | 5 |
| 3 | 2 | 1 | 1 | 2 | 2 |
| 4 | 2 | 2 | 2 | 3 | 3 |

## Pertanyaan Penelitian

**Apakah ada perubahan signifikan dari waktu ke waktu?** (Apakah ada pertumbuhan, penurunan, atau stabilitas secara keseluruhan?)

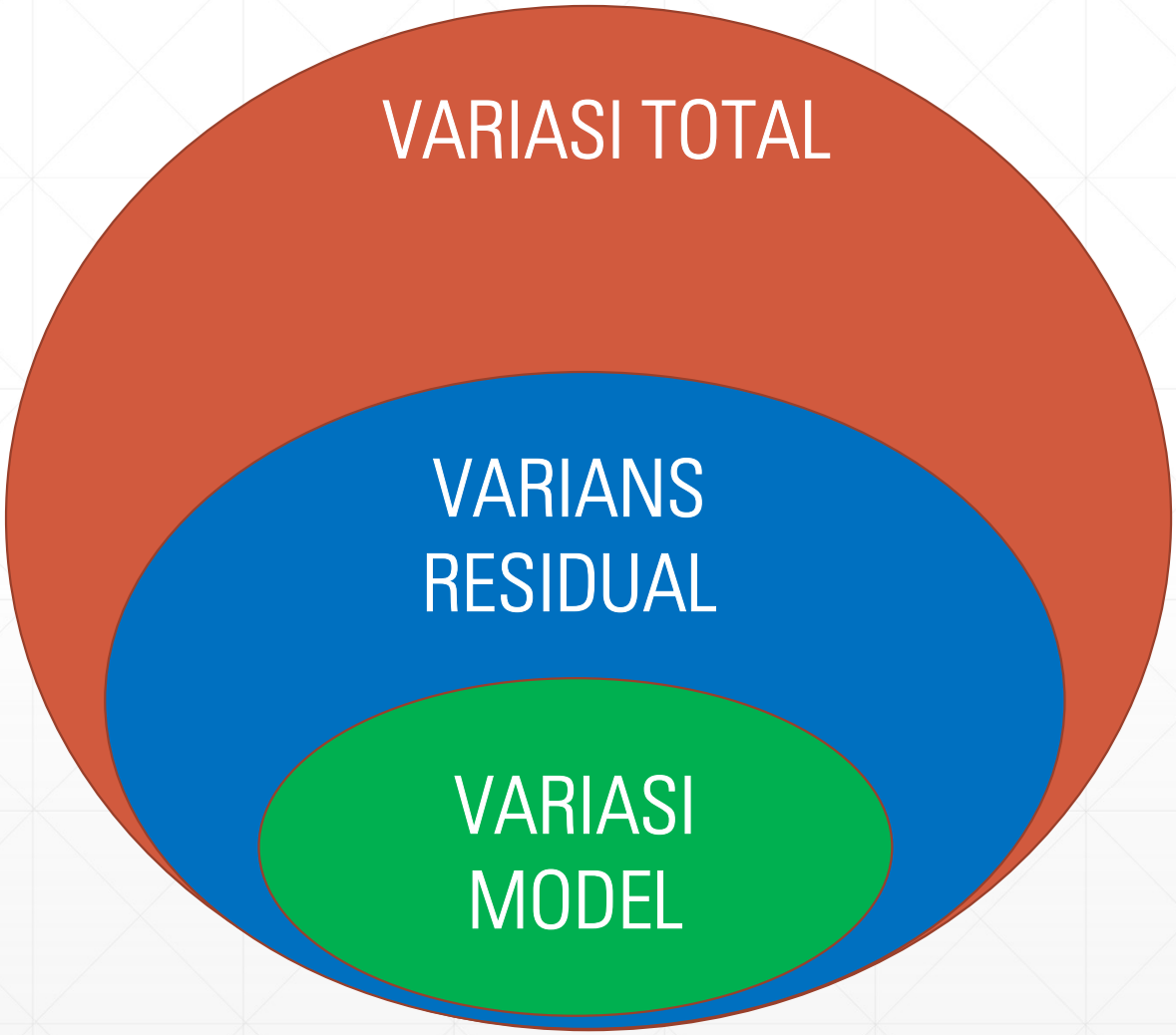
**Apakah tingkat perubahan (slope) berbeda antar kelompok?** (Apakah intervensi yang diberikan kepada Grup 1 menghasilkan peningkatan yang lebih cepat dibandingkan dengan Grup 2?)

**Apakah ada perbedaan rata-rata antar kelompok pada titik waktu awal (intercept)?** (Apakah Grup 1 dan Grup 2 sudah memiliki perbedaan sebelum intervensi dimulai?)

**Faktor-faktor apa yang memprediksi perubahan individu?** (Jika dikaitkan dengan prediktor).

•**Apakah ada efek waktu non-linear?** (Apakah peningkatannya cepat di awal lalu melambat?) Dalam data ini, peningkatannya tampak cukup linear untuk Grup 1, tetapi mungkin sedikit non-linear untuk Grup 2.

| Subjek | Grup | T1 | T2 | T3 | T4 |
|---|---|---|---|---|---|
| A1 | 1 | 1 | 2 | 3 | 4 |
| A2 | 1 | 2 | 3 | 4 | 5 |
| A3 | 1 | 1 | 2 | 3 | 4 |
| A4 | 2 | 1 | 2 | 1 | 2 |
| A5 | 2 | 2 | 3 | 2 | 3 |
| A6 | 2 | 1 | 2 | 1 | 2 |
| A7 | 3 | 1 | 4 | 9 | 15 |
| A8 | 3 | 2 | 6 | 11 | 16 |
| A9 | 3 | 1 | 4 | 9 | 15 |


VARIASI TOTAL
VARIANS
RESIDUAL
VARIASI
MODEL

# Tabel Hasil Analisis Anava Amatan Ulang Secara Lengkap

Table 3. Summary table for the one-way repeated measures ANOVA

| | Sum of squares | Degree of freedom | Mean squares | F | Effect size (partial eta-squared) |
|---|---|---|---|---|---|
| Subject | 704.96 | $n$ - 1 = 7 | 100.78 | | |
| Conditions | 152.33 (SSB) | K - 1 = 2 | 76.16 | 15.31 ($p$ < 0.0001) | 152.33 / (152.33 + 69.67) = 0.69 |
| Residual | 69.67 (SSE) | ($n$ - 1)(k - 1) = 14 | 4.98 | (MS by condition / MS Residual) | [SS by condition / (SS by condition + SS residual)] |
| Total | 926.96 (SST) | ($n$)(k) - 1 = 24 - 1 = 23 | | | |

# Longitudinal Data

# Format Data

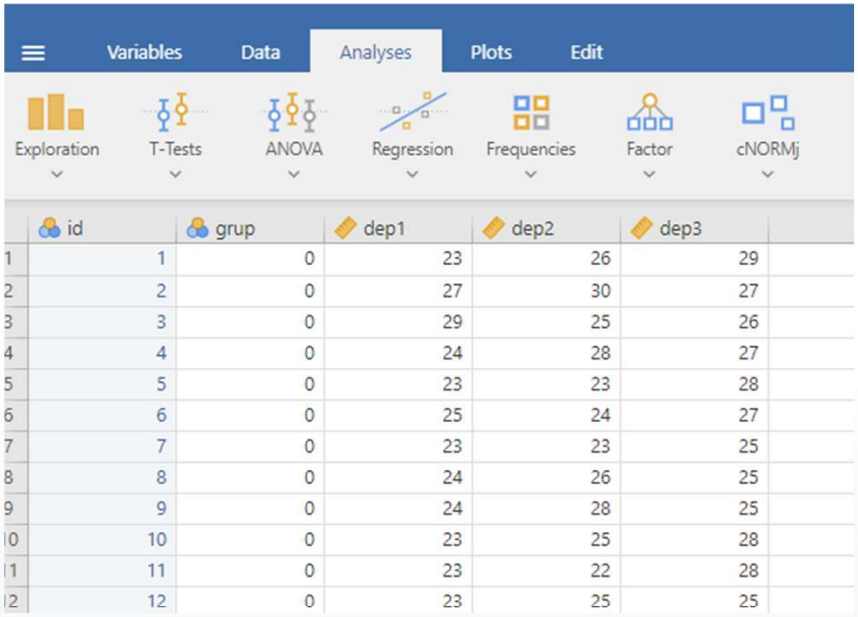
| | Subject | Gender | Region | Education | LDLF | LDHF | HDLF | HDHF |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | Female | North America | some | 6.0 | 6.0 | 9.0 | 10.0 |
| 2 | 2 | Female | North America | advance | 10.0 | | 10.0 | 10.0 |
| 3 | 3 | Female | Europe | college | 5.0 | 10.0 | 10.0 | 10.0 |
| 4 | 4 | Female | North America | college | 6.0 | 9.0 | 6.0 | 9.0 |
| 5 | 5 | Female | North America | some | 3.0 | 6.5 | 5.5 | 8.5 |
| 6 | 6 | Female | Europe | some | 2.0 | 0.5 | 7.5 | 3.0 |
| 7 | 7 | Female | North America | some | 10.0 | 10.0 | 10.0 | 10.0 |
| 8 | 8 | Female | North America | high | 10.0 | 10.0 | 9.0 | 10.0 |
| 9 | 9 | Female | North America | high | 9.5 | 9.5 | 6.0 | 10.0 |
| 10 | 10 | Female | Other | high | 8.5 | 10.0 | 7.0 | |
| 11 | 11 | Male | North America | some | 0.0 | 2.5 | 0.0 | 0.0 |
| 12 | 12 | Male | North America | some | 9.5 | 7.5 | 8.5 | 10.0 |
| 13 | 13 | Female | North America | less | 7.0 | 8.5 | 6.5 | 8.5 |
| 14 | 14 | Female | North America | some | 3.0 | 8.0 | 4.0 | 8.5 |
| 15 | 15 | Male | North America | some | 4.0 | 5.0 | 6.0 | 7.0 |
| 16 | 16 | Male | North America | high | 7.0 | 8.5 | 8.5 | 9.0 |
| 17 | 17 | Male | North America | some | 2.0 | 6.0 | 10.0 | 10.0 |

**Width Format**

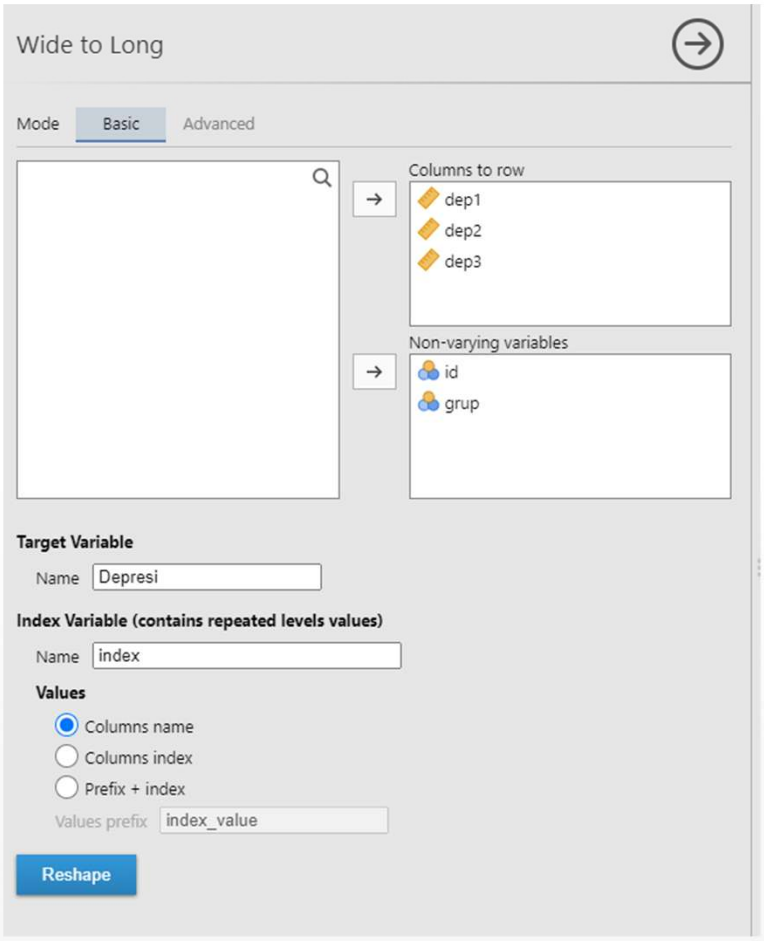
| | Subject | Gender | Region | Education | Disgust | Fright | Rating |
|---|---|---|---|---|---|---|---|
| 1 | 1 | Female | North America | some | Low | Low | 6.0 |
| 2 | 1 | Female | North America | some | Low | High | 6.0 |
| 3 | 1 | Female | North America | some | High | Low | 9.0 |
| 4 | 1 | Female | North America | some | High | High | 10.0 |
| 5 | 2 | Female | North America | advance | Low | Low | 10.0 |
| 6 | 2 | Female | North America | advance | Low | High | |
| 7 | 2 | Female | North America | advance | High | Low | 10.0 |
| 8 | 2 | Female | North America | advance | High | High | 10.0 |
| 9 | 3 | Female | Europe | college | Low | Low | 5.0 |
| 10 | 3 | Female | Europe | college | Low | High | 10.0 |
| 11 | 3 | Female | Europe | college | High | Low | 10.0 |
| 12 | 3 | Female | Europe | college | High | High | 10.0 |
| 13 | 4 | Female | North America | college | Low | Low | 6.0 |
| 14 | 4 | Female | North America | college | Low | High | 9.0 |
| 15 | 4 | Female | North America | college | High | Low | 6.0 |
| 16 | 4 | Female | North America | college | High | High | 9.0 |

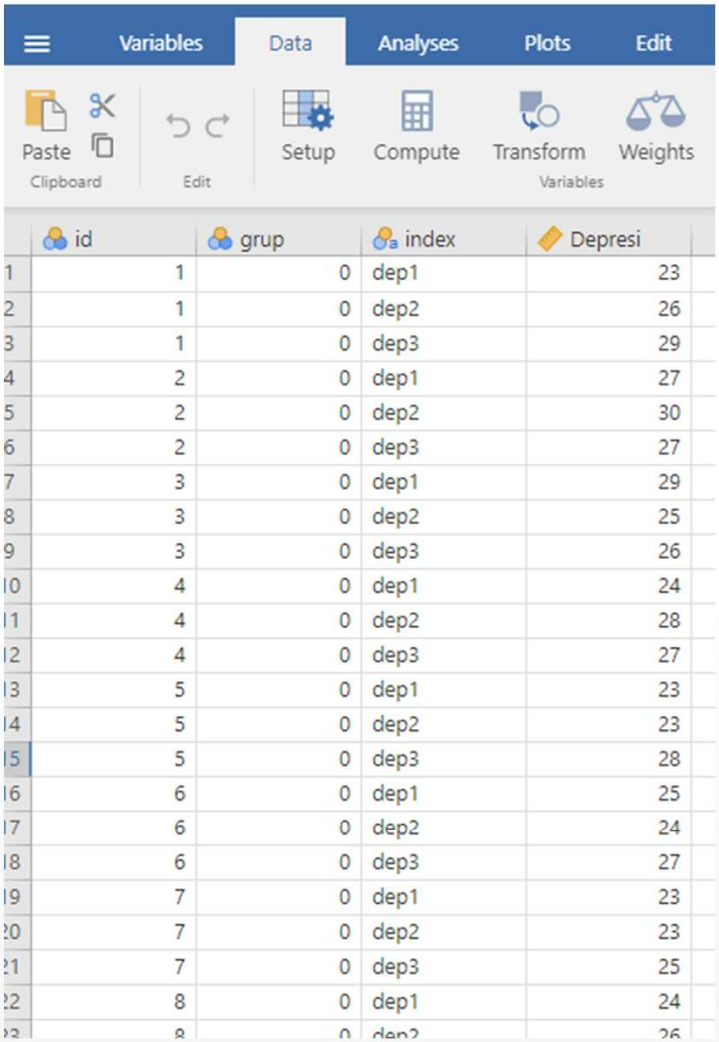
**Long Format**

# Package Jreshape



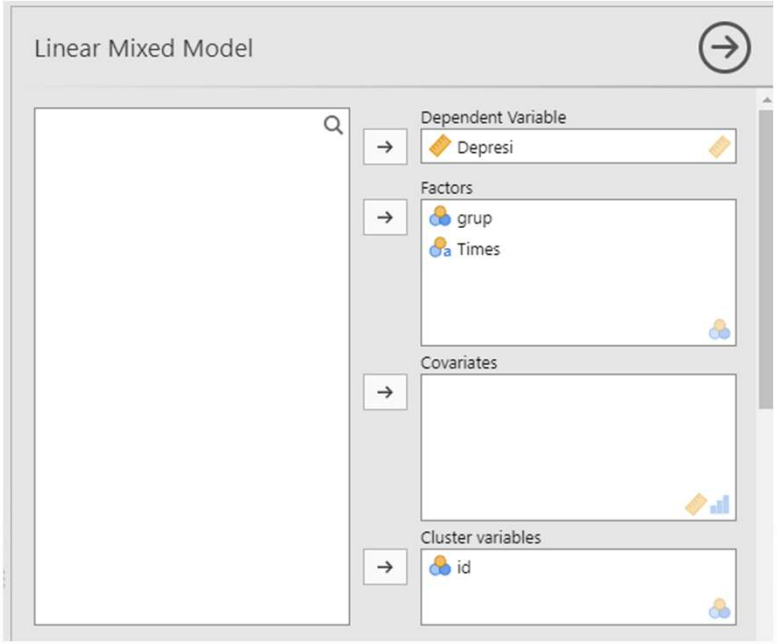

| | id | grup | dep1 | dep2 | dep3 |
|---|---|---|---|---|---|
| 1 | 1 | 0 | 23 | 26 | 29 |
| 2 | 2 | 0 | 27 | 30 | 27 |
| 3 | 3 | 0 | 29 | 25 | 26 |
| 4 | 4 | 0 | 24 | 28 | 27 |
| 5 | 5 | 0 | 23 | 23 | 28 |
| 6 | 6 | 0 | 25 | 24 | 27 |
| 7 | 7 | 0 | 23 | 23 | 25 |
| 8 | 8 | 0 | 24 | 26 | 25 |
| 9 | 9 | 0 | 24 | 28 | 25 |
| 10 | 10 | 0 | 23 | 25 | 28 |
| 11 | 11 | 0 | 23 | 22 | 28 |
| 12 | 12 | 0 | 23 | 25 | 25 |






| | id | grup | index | Depresi |
|---|---|---|---|---|
| 1 | 1 | 0 | dep1 | 23 |
| 2 | 1 | 0 | dep2 | 26 |
| 3 | 1 | 0 | dep3 | 29 |
| 4 | 2 | 0 | dep1 | 27 |
| 5 | 2 | 0 | dep2 | 30 |
| 6 | 2 | 0 | dep3 | 27 |
| 7 | 3 | 0 | dep1 | 29 |
| 8 | 3 | 0 | dep2 | 25 |
| 9 | 3 | 0 | dep3 | 26 |
| 10 | 4 | 0 | dep1 | 24 |
| 11 | 4 | 0 | dep2 | 28 |
| 12 | 4 | 0 | dep3 | 27 |
| 13 | 5 | 0 | dep1 | 23 |
| 14 | 5 | 0 | dep2 | 23 |
| 15 | 5 | 0 | dep3 | 28 |
| 16 | 6 | 0 | dep1 | 25 |
| 17 | 6 | 0 | dep2 | 24 |
| 18 | 6 | 0 | dep3 | 27 |
| 19 | 7 | 0 | dep1 | 23 |
| 20 | 7 | 0 | dep2 | 23 |
| 21 | 7 | 0 | dep3 | 25 |
| 22 | 8 | 0 | dep1 | 24 |
| 23 | 8 | 0 | dep2 | 26 |

# Package GAMLj

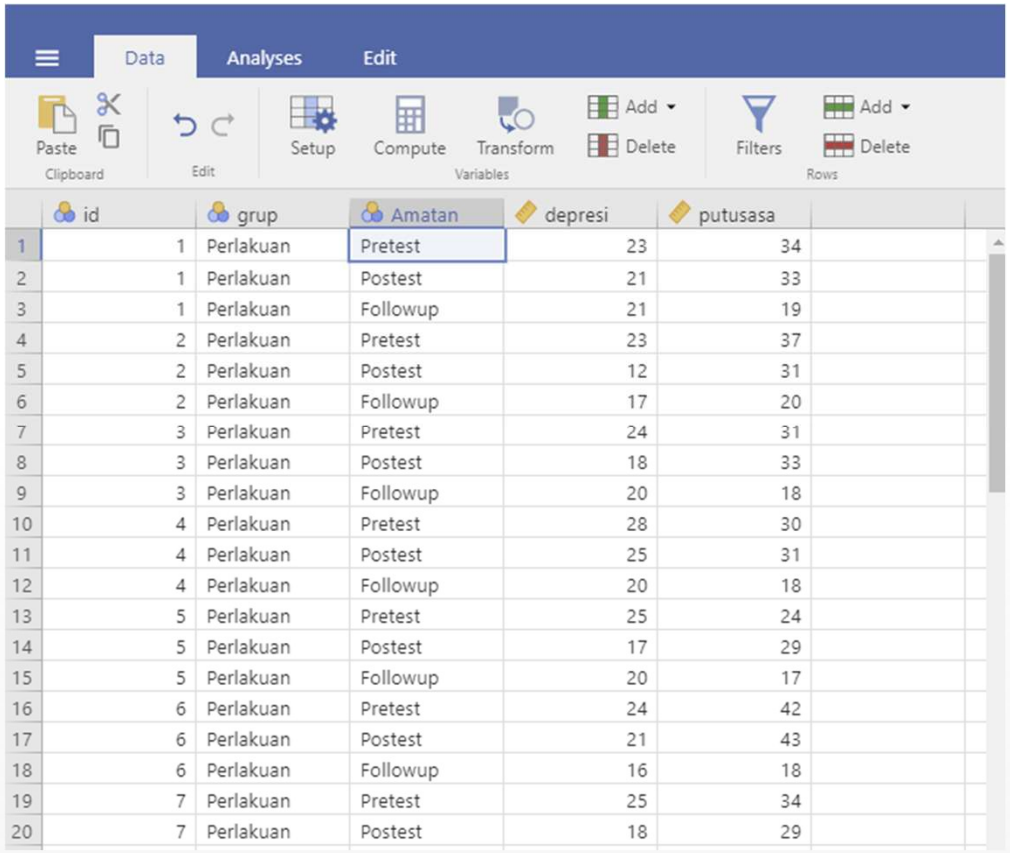



**Factor/Covariate** = variabel tetap yang ingin diuji secara eksplisit dalam model.

**Cluster** = Unit pengelompokan acak yang ingin divariasikan dalam intercept/slope berbeda. Biasanya data di level tinggi

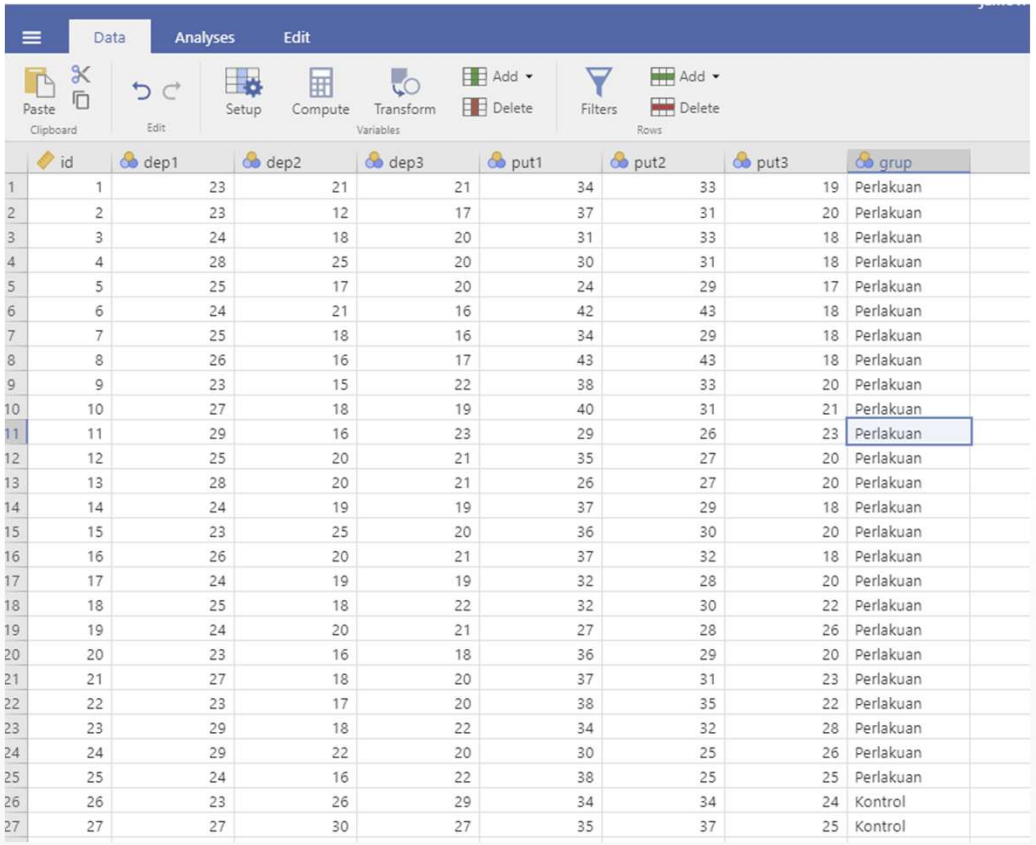
# Format Data

## Width Format




| | id | grup | Amatan | depresi | putusasa |
|---|---|---|---|---|---|
| 1 | 1 | Perlakuan | Pretest | 23 | 34 |
| 2 | 1 | Perlakuan | Postest | 21 | 33 |
| 3 | 1 | Perlakuan | Followup | 21 | 19 |
| 4 | 2 | Perlakuan | Pretest | 23 | 37 |
| 5 | 2 | Perlakuan | Postest | 12 | 31 |
| 6 | 2 | Perlakuan | Followup | 17 | 20 |
| 7 | 3 | Perlakuan | Pretest | 24 | 31 |
| 8 | 3 | Perlakuan | Postest | 18 | 33 |
| 9 | 3 | Perlakuan | Followup | 20 | 18 |
| 10 | 4 | Perlakuan | Pretest | 28 | 30 |
| 11 | 4 | Perlakuan | Postest | 25 | 31 |
| 12 | 4 | Perlakuan | Followup | 20 | 18 |
| 13 | 5 | Perlakuan | Pretest | 25 | 24 |
| 14 | 5 | Perlakuan | Postest | 17 | 29 |
| 15 | 5 | Perlakuan | Followup | 20 | 17 |
| 16 | 6 | Perlakuan | Pretest | 24 | 42 |
| 17 | 6 | Perlakuan | Postest | 21 | 43 |
| 18 | 6 | Perlakuan | Followup | 16 | 18 |
| 19 | 7 | Perlakuan | Pretest | 25 | 34 |
| 20 | 7 | Perlakuan | Postest | 18 | 29 |

## Long Format




| | id | dep1 | dep2 | dep3 | put1 | put2 | put3 | grup |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 23 | 21 | 21 | 34 | 33 | 19 | Perlakuan |
| 2 | 2 | 23 | 12 | 17 | 37 | 31 | 20 | Perlakuan |
| 3 | 3 | 24 | 18 | 20 | 31 | 33 | 18 | Perlakuan |
| 4 | 4 | 28 | 25 | 20 | 30 | 31 | 18 | Perlakuan |
| 5 | 5 | 25 | 17 | 20 | 24 | 29 | 17 | Perlakuan |
| 6 | 6 | 24 | 21 | 16 | 42 | 43 | 18 | Perlakuan |
| 7 | 7 | 25 | 18 | 16 | 34 | 29 | 18 | Perlakuan |
| 8 | 8 | 26 | 16 | 17 | 43 | 43 | 18 | Perlakuan |
| 9 | 9 | 23 | 15 | 22 | 38 | 33 | 20 | Perlakuan |
| 10 | 10 | 27 | 18 | 19 | 40 | 31 | 21 | Perlakuan |
| 11 | 11 | 29 | 16 | 23 | 29 | 26 | 23 | Perlakuan |
| 12 | 12 | 25 | 20 | 21 | 35 | 27 | 20 | Perlakuan |
| 13 | 13 | 28 | 20 | 21 | 26 | 27 | 20 | Perlakuan |
| 14 | 14 | 24 | 19 | 19 | 37 | 29 | 18 | Perlakuan |
| 15 | 15 | 23 | 25 | 20 | 36 | 30 | 20 | Perlakuan |
| 16 | 16 | 26 | 20 | 21 | 37 | 32 | 18 | Perlakuan |
| 17 | 17 | 24 | 19 | 19 | 32 | 28 | 20 | Perlakuan |
| 18 | 18 | 25 | 18 | 22 | 32 | 30 | 22 | Perlakuan |
| 19 | 19 | 24 | 20 | 21 | 27 | 28 | 26 | Perlakuan |
| 20 | 20 | 23 | 16 | 18 | 36 | 29 | 20 | Perlakuan |
| 21 | 21 | 27 | 18 | 20 | 37 | 31 | 23 | Perlakuan |
| 22 | 22 | 23 | 17 | 20 | 38 | 35 | 22 | Perlakuan |
| 23 | 23 | 29 | 18 | 22 | 34 | 32 | 28 | Perlakuan |
| 24 | 24 | 29 | 22 | 20 | 30 | 25 | 26 | Perlakuan |
| 25 | 25 | 24 | 16 | 22 | 38 | 25 | 25 | Perlakuan |
| 26 | 26 | 23 | 26 | 29 | 34 | 34 | 24 | Kontrol |
| 27 | 27 | 27 | 30 | 27 | 35 | 37 | 25 | Kontrol |

Home > Resources > Data Tools > Long and Wide Data Format Converter

# Long and Wide Data Format Converter

Created: December 17, 2024 Last Updated: September 4, 2025

## Tool

### 1. Upload Your Data

Not sure about data formats? Check out the examples in the Learn More section below. Save your data when you are done because this tool does not save your data anywhere.

Import Data for Transformation

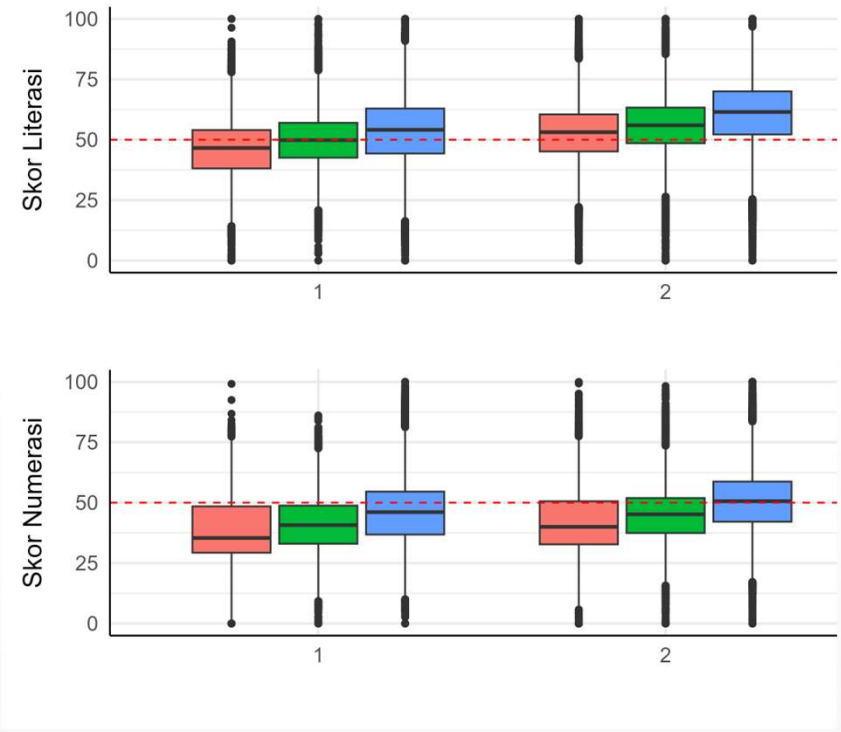
## Learn More

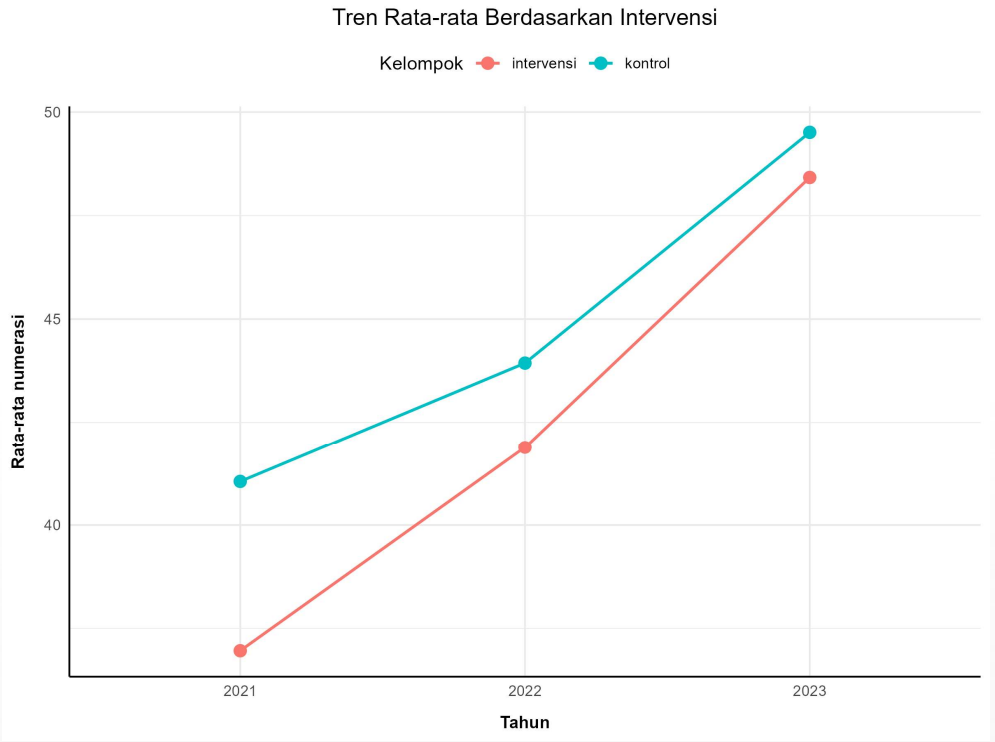
https://www.statscalculators.com/resources/data-tools/long-and-wide-data-format-converter#google_vignette

# Perbedaan antara Anova RM vs Analisis Regresi pada data longitudinal

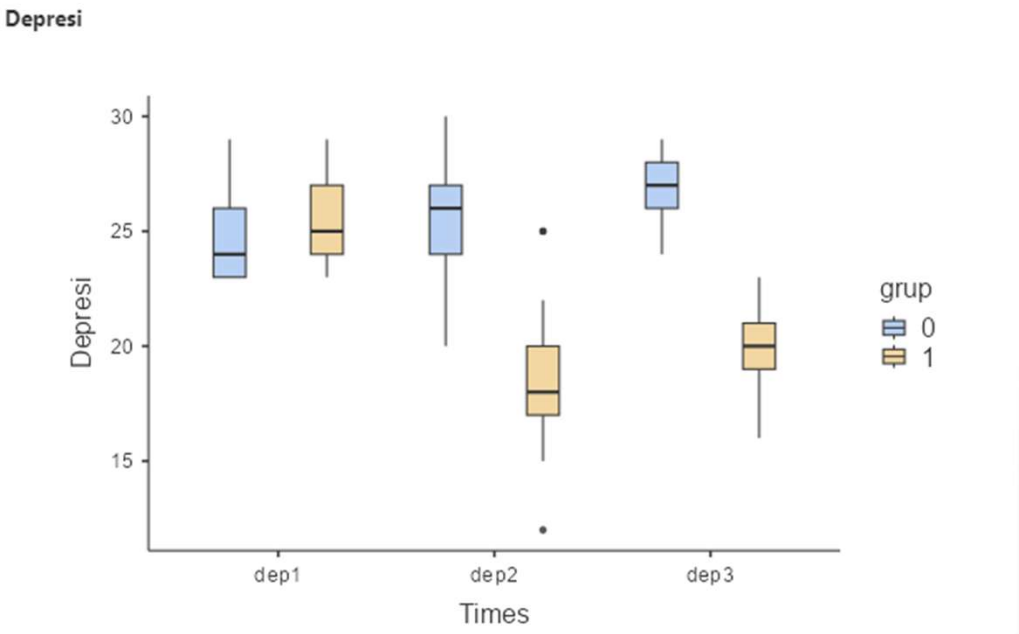
| Aspek | RM-ANOVA | Regresi Longitudinal (Mixed Model) |
|---|---|---|
| **Tujuan utama** | Menguji perbedaan rerata antar waktu dan grup | Memodelkan perubahan skor sebagai fungsi waktu dan prediktor |
| **Fokus analisis** | Rerata dan varians (kontras waktu x grup) | Prediksi dan estimasi efek tetap & acak |
| **Struktur data** | Balanced, lengkap, semua subjek punya data di semua waktu | Bisa menangani data tidak lengkap atau tidak seimbang |
| **Asumsi korelasi** | Sphericity (varians dan korelasi antar waktu sama) | Korelasi antar waktu bisa fleksibel (autoregressive, unstructured) |
| **Handling missing data** | Tidak robust terhadap missing (listwise deletion) | Bisa menangani missing dengan asumsi MAR (Mixed Model) |
| **Efek acak** | Tidak dimodelkan eksplisit (ada menu random effect di software) | Bisa memasukkan random intercept/slope per subjek |
| **Interaksi waktu x grup** | Diuji via kontras | Diestimasi sebagai interaksi prediktor |

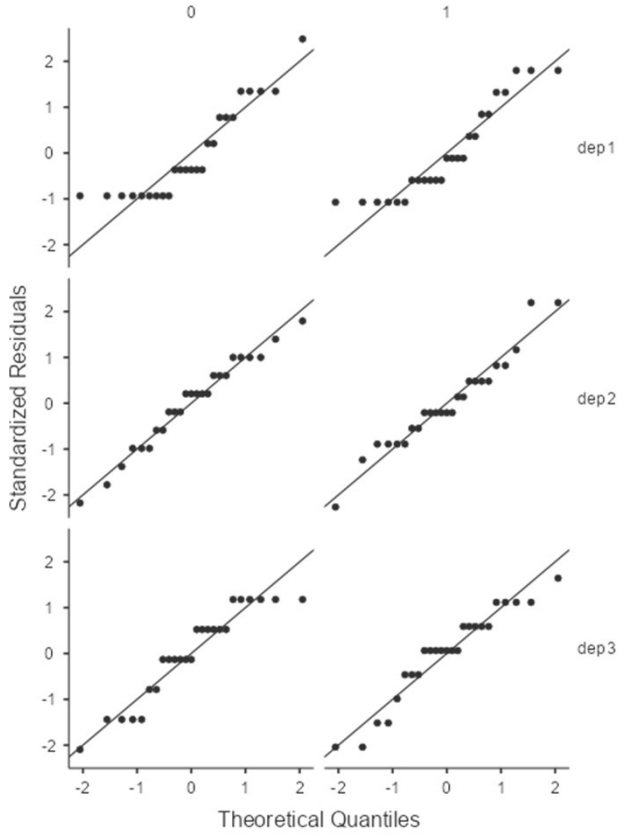
# Perbandingan Plot Anova RM vs Mixed Model

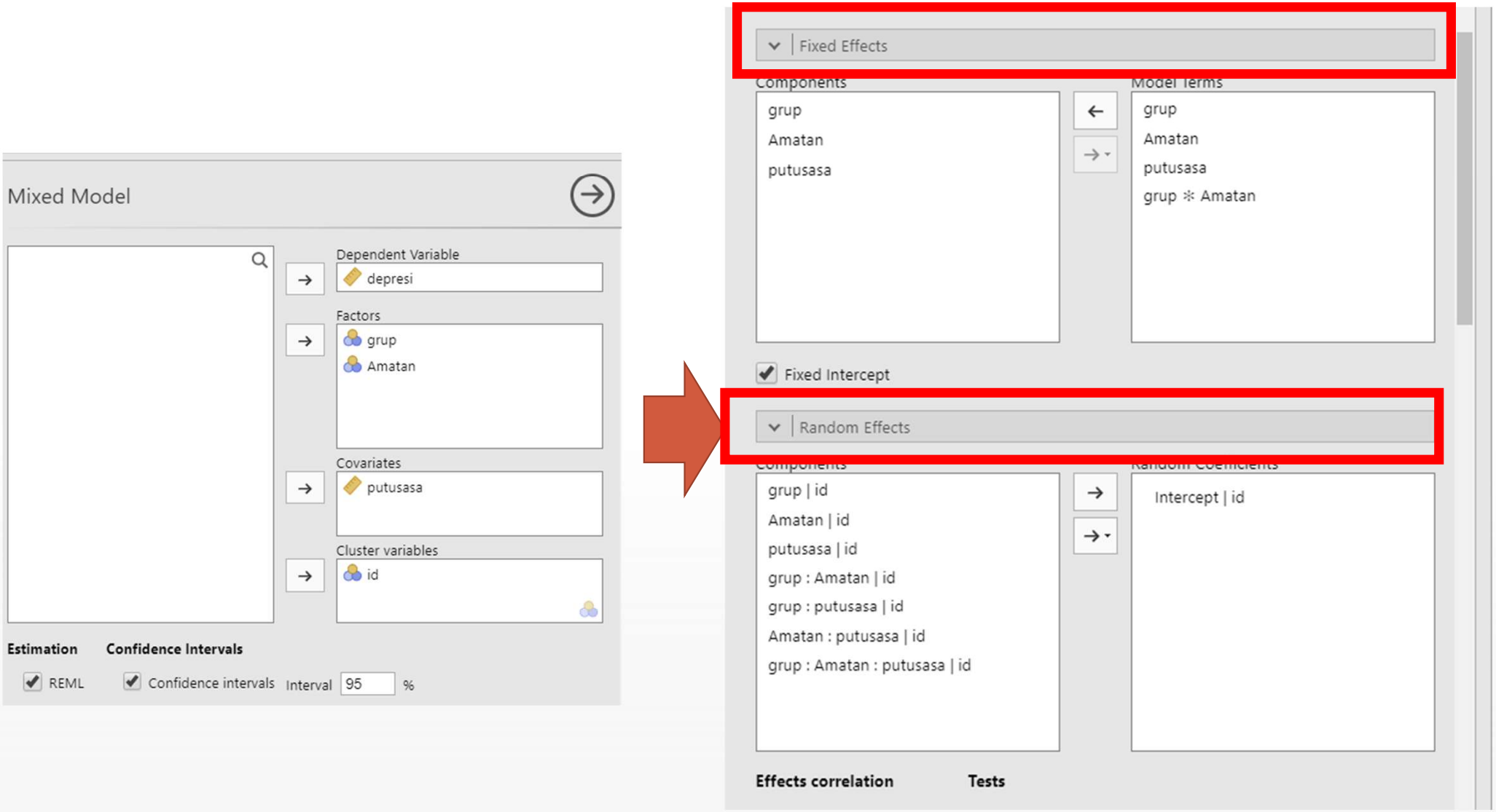


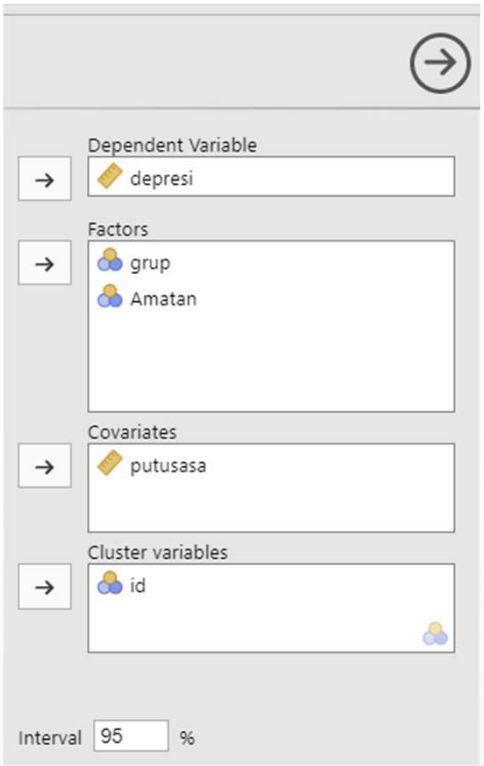
# Perbandingan Plot Anova RM vs Mixed Model




Mixed Model
Dependent Variable
depresi
Factors
grup
Amatan
Covariates
putusasa
Cluster variables
id
Estimation
REML
Confidence Intervals
Confidence intervals
Interval
95
%
Fixed Effects
Components
grup
Amatan
putusasa
Model Terms
grup
Amatan
putusasa
grup * Amatan
Fixed Intercept
Random Effects
grup | id
Amatan | id
putusasa | id
grup : Amatan | id
grup : putusasa | id
Amatan : putusasa | id
grup : Amatan : putusasa | id
Intercept | id
Effects correlation
Tests

# Apa variabel yang parameternya dibuat random




| Aspek | ID | Grup |
|---|---|---|
| **Level efek acak** | Subjek (individu) | Grup (perlakuan, sekolah) |
| **Tujuan** | Menangkap variasi antar individu | Menangkap variasi antar grup |
| **Cocok untuk** | Longitudinal, repeated measures | Clustered data, nested design |
| **Variabilitas yang ditangkap** | Baseline tiap individu berbeda | Baseline tiap grup berbeda |
| **Model yang dihasilkan** | Lebih granular dan fleksibel | Lebih agregatif dan sederhana |

# Fixed Effect: Anova RM vs Mixed Effect

ANOVA

Within Subjects Effects

| | Sum of Squares | df | Mean Square | F | p |
|---|---|---|---|---|---|
| RM Factor 1 | 210 | 2 | 105.17 | 25.7 | < .001 |
| RM Factor 1 ✻ grup | 495 | 2 | 247.65 | 60.6 | < .001 |
| Residual | 392 | 96 | 4.09 | | |

*Note.* Type 3 Sums of Squares

[3]

Post Hoc Comparisons - grup

| Comparison | | | | | | | |
|---|---|---|---|---|---|---|---|
| grup | | grup | Mean Difference | SE | df | t | $P_{tukey}$ |
| 0 | - | 1 | 4.53 | 0.398 | 48.0 | 11.4 | < .001 |

MIXED MODEL

Parameter Estimates (Fixed coefficients)

| | | | | 95% Confidence Intervals | | | | |
|---|---|---|---|---|---|---|---|---|
| Names | Effect | Estimate | SE | Lower | Upper | df | t | p |
| (Intercept) | (Intercept) | 23.51 | 0.199 | 23.11 | 23.900 | 48.0 | 118.19 | < .001 |
| grup1 | 1 - 0 | −4.53 | 0.398 | −5.32 | −3.747 | 48.0 | −11.40 | < .001 |
| Times1 | dep2 - dep1 | −2.90 | 0.404 | −3.70 | −2.101 | 96.0 | −7.17 | < .001 |
| Times2 | dep3 - dep1 | −1.40 | 0.404 | −2.20 | −0.601 | 96.0 | −3.46 | < .001 |
| grup1 ✻ Times1 | (1 - 0) ✻ (dep2 - dep1) | −7.48 | 0.809 | −9.08 | −5.881 | 96.0 | −9.25 | < .001 |
| grup1 ✻ Times2 | (1 - 0) ✻ (dep3 - dep1) | −7.92 | 0.809 | −9.52 | −6.321 | 96.0 | −9.79 | < .001 |

[5]

# Random Effect dalam Mixed Model

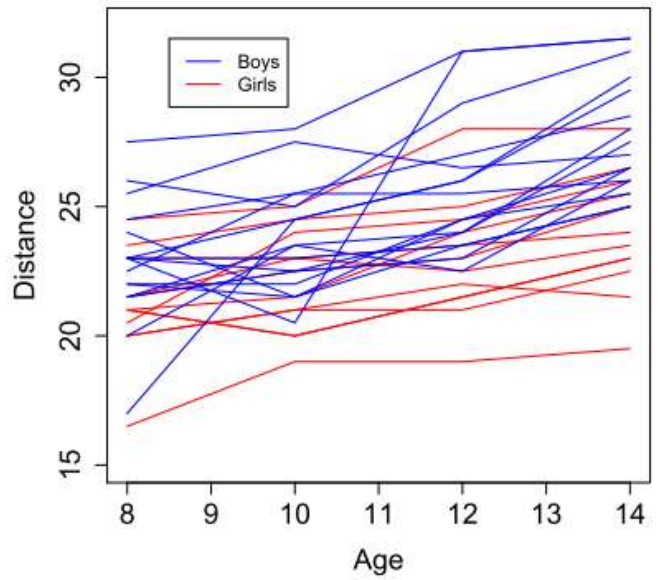
Random Components

| Groups | Name | SD | Variance | ICC |
|---|---|---|---|---|
| id | (Intercept) | 0.705 | 0.497 | 0.107 |
| Residual | | 2.041 | 4.166 | |

*Note.* Number of Obs: 150 , groups: id 50

ICC mengukur proporsi total varians dalam variabel dependen yang dapat diatribusikan pada variabel pengelompokan ('id'). Dalam kasus ini, [10.7%] dari total varians dalam hasil disebabkan oleh perbedaan antara grup 'id'. ICC yang lebih tinggi menunjukkan bahwa pengamatan dalam grup yang sama lebih mirip satu sama lain dibandingkan dengan pengamatan dari grup yang berbeda.

Sekitar 10.7% dari total varians berasal dari perbedaan antar grup (id), sisanya berasal dari variasi dalam individu.




- Linear model plausible, but height differences between girls and boys. Growth at same speed??

- Model with interaction:

$$E(Y_{ij}) = \beta_0 + \beta_1 t_{ij} + \beta_2 G_i + \beta_3 G_i t_{ij},$$

$\mathbf{X}_i$ contains rows $[1 \;\; G_i \;\; t_{ij} \;\; G_i t_{ij}]$.

# Kasus Analisis:
# Riset Non Eksperimen

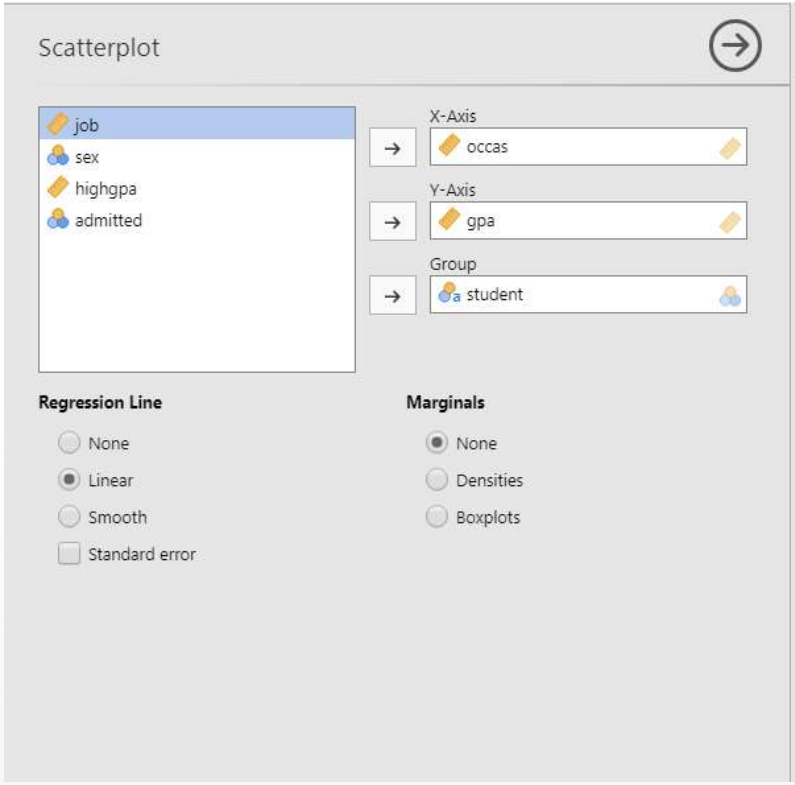
## Data Set (Hox et.al, 2018)

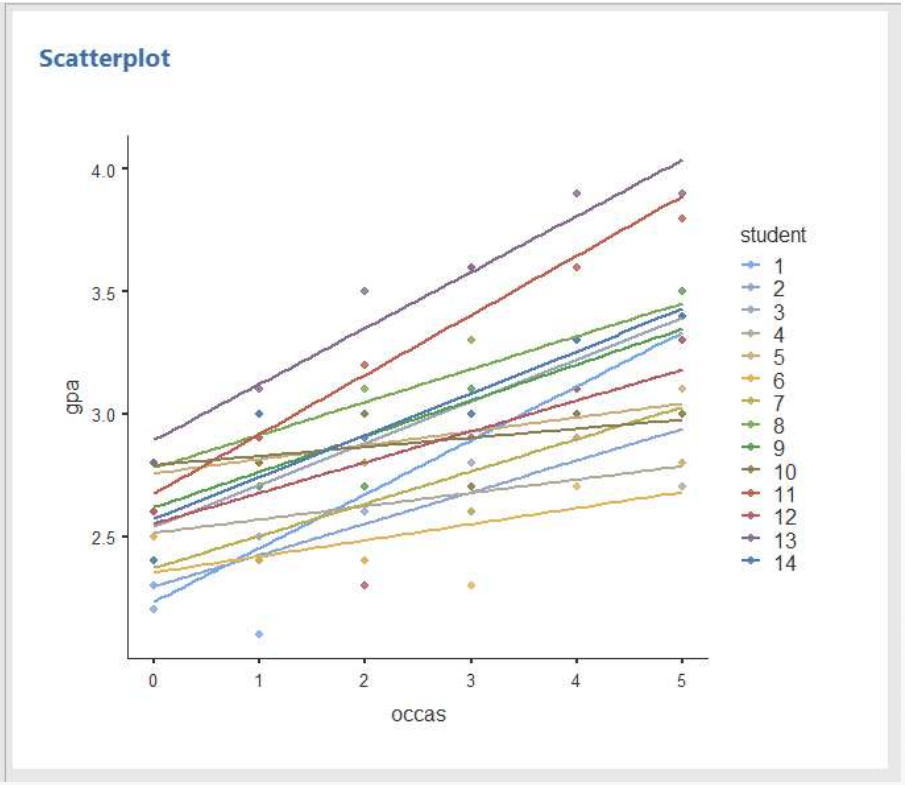
- A longitudinal data set from 200 college students. The students' Grade Point Average (GPA) has been recorded for 6 successive semesters.
- It was recorded whether the student held a job in that semester, and for how many hours. This is recorded in a variable 'job' (with categories 0=no job, 1=1 hour, 2=2 hours, 3=3 hours, 4=4 or more hours), which for the purpose of this example is treated as an interval level variable.
- We also use the student variables high school GPA and gender (1=male, 2=female), which of course remain constant for each student across the six time points.

# Tampilan Data

| student | idstud | occas | gpa | job | sex | highgpa | admitted |
|---|---|---|---|---|---|---|---|
| 1 | 1 | year 1 semes... | 2.3 | 2 hours | female | 2.8 | yes |
| 1 | 1 | year 1 semes... | 2.1 | 2 hours | female | 2.8 | yes |
| 1 | 1 | year 2 semes... | 3.0 | 2 hours | female | 2.8 | yes |
| 1 | 1 | year 2 semes... | 3.0 | 2 hours | female | 2.8 | yes |
| 1 | 1 | year 3 semes... | 3.0 | 2 hours | female | 2.8 | yes |
| 1 | 1 | year 3 semes... | 3.3 | 2 hours | female | 2.8 | yes |
| 2 | 2 | year 1 semes... | 2.2 | 2 hours | male | 2.5 | no |
| 2 | 2 | year 1 semes... | 2.5 | 3 hours | male | 2.5 | no |
| 2 | 2 | year 2 semes... | 2.6 | 2 hours | male | 2.5 | no |
| 2 | 2 | year 2 semes... | 2.6 | 2 hours | male | 2.5 | no |
| 2 | 2 | year 3 semes... | 3.0 | 2 hours | male | 2.5 | no |
| 2 | 2 | year 3 semes... | 2.8 | 2 hours | male | 2.5 | no |
| 3 | 3 | year 1 semes... | 2.4 | 2 hours | female | 2.5 | yes |
| 3 | 3 | year 1 semes... | 2.9 | 2 hours | female | 2.5 | yes |
| 3 | 3 | year 2 semes... | 3.0 | 2 hours | female | 2.5 | yes |
| 3 | 3 | year 2 semes... | 2.8 | 3 hours | female | 2.5 | yes |
| 3 | 3 | year 3 semes... | 3.3 | 2 hours | female | 2.5 | yes |
| 3 | 3 | year 3 semes... | 3.4 | 2 hours | female | 2.5 | yes |
| 4 | 4 | year 1 semes... | 2.5 | 3 hours | male | 3.8 | no |
| 4 | 4 | year 1 semes... | 2.7 | 2 hours | male | 3.8 | no |
| 4 | 4 | year 2 semes... | 2.4 | 2 hours | male | 3.8 | no |
| 4 | 4 | year 2 semes... | 2.7 | 2 hours | male | 3.8 | no |
| 4 | 4 | year 3 semes... | 2.9 | 2 hours | male | 3.8 | no |

# Kondisi Data



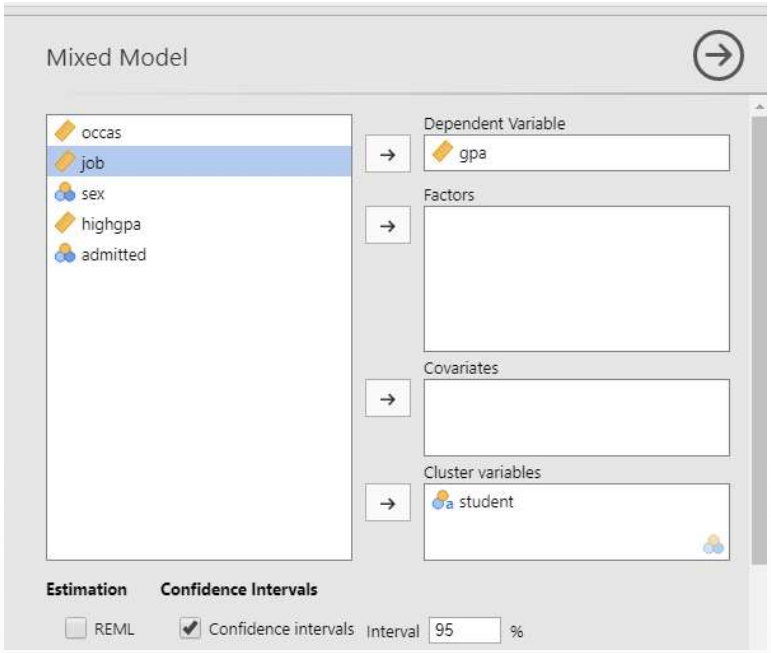



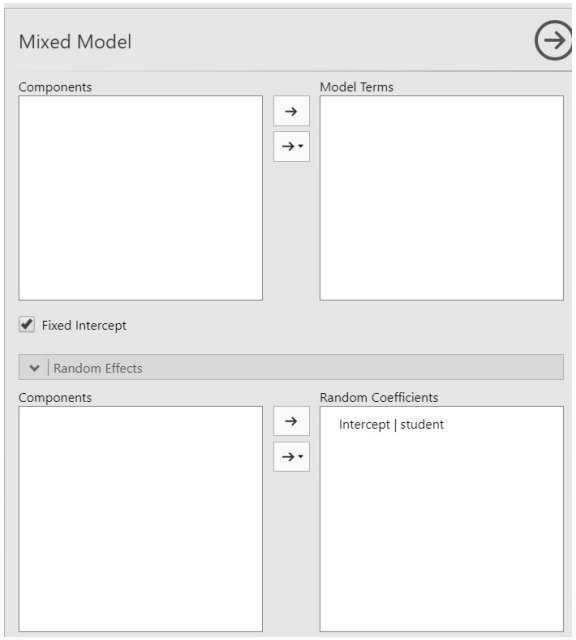
# Model 1 - Null (no predictors) model

$$\left.\begin{aligned} y_{ti} &= \pi_{0i} + \varepsilon_{ti} \\ \pi_{0i} &= \beta_{00} + \mu_{0i} \end{aligned}\right\} y_{ti} = \beta_{00} + \mu_{0i} + \varepsilon_{ti}$$

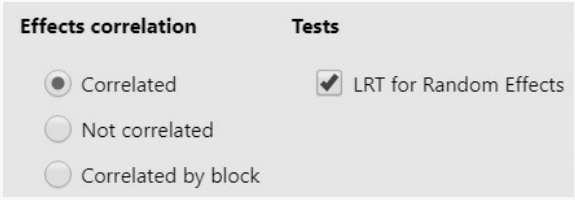
- Model ini mengizinkan setiap individu memiliki baseline depresi yang berbeda, tapi tetap mengacu pada rata-rata populasi.
- Variabilitas antar individu ditangkap oleh mu, dan variabilitas dalam individu dari waktu ke waktu ditangkap oleh epsilon.
- Ini adalah bentuk *random intercept model*, yang cocok untuk analisis awal data longitudinal atau nested.

# Model 1 - Null (no predictors) model




"Korelasi efek" merujuk pada matriks kovarians Level 2 untuk efek acak. Karena hanya intercept yang diperlakukan sebagai efek acak, pengaturan default ini dapat dibiarkan apa adanya. "Uji Rasio Likelihood (LRT) untuk Efek Acak" akan menghasilkan pengujian rasio likelihood terhadap komponen varians.



# Keluaran Hasil

**Model Results**

Fixed Effect Omnibus tests

| | F | Num df | Den df | p |
|---|---|---|---|---|

Fixed Effects Parameter Estimates

| | | | 95% Confidence Interval | | |
|---|---|---|---|---|---|
| Names | Estimate | SE | Lower | Upper | df |
| (Intercept) | 2.87 | 0.0191 | 2.83 | 2.90 | 200 |

Random Components

| Groups | Name | SD | Variance | ICC |
|---|---|---|---|---|
| student | (Intercept) | 0.238 | 0.0568 | 0.368 |
| Residual | | 0.312 | 0.0976 | |

Random Effect LRT

| Test | N. par | AIC | LRT | df | p |
|---|---|---|---|---|---|
| (1 \| student) | 2.00 | 1167 | 250 | 1.00 | < .001 |

**Efek Tetap (Fixed Effects)**

- Intercept sebesar 0.238, dengan standard error 0.0191 dan interval kepercayaan 95% antara 0.202 hingga 0.274. Nilai t = 150 dan p < .001, (signifikan).
- Artinya, rata-rata skor depresi awal (baseline) secara keseluruhan berada di sekitar 0.238, sebelum mempertimbangkan pengaruh waktu atau grup.

**Efek Acak (Random Effects)**

- Efek acak intercept antar siswa memiliki SD=0.0568, yang berarti ada variasi baseline depresi antar individu.
- ICC = 0.368, 36.8% varians skor depresi berasal dari perbedaan antar siswa, bukan dari fluktuasi dalam individu. (cukup tinggi).
- Residual variance sebesar 0.0976 (SD = 0.312), menunjukkan sisa varians yang tidak dijelaskan oleh model.

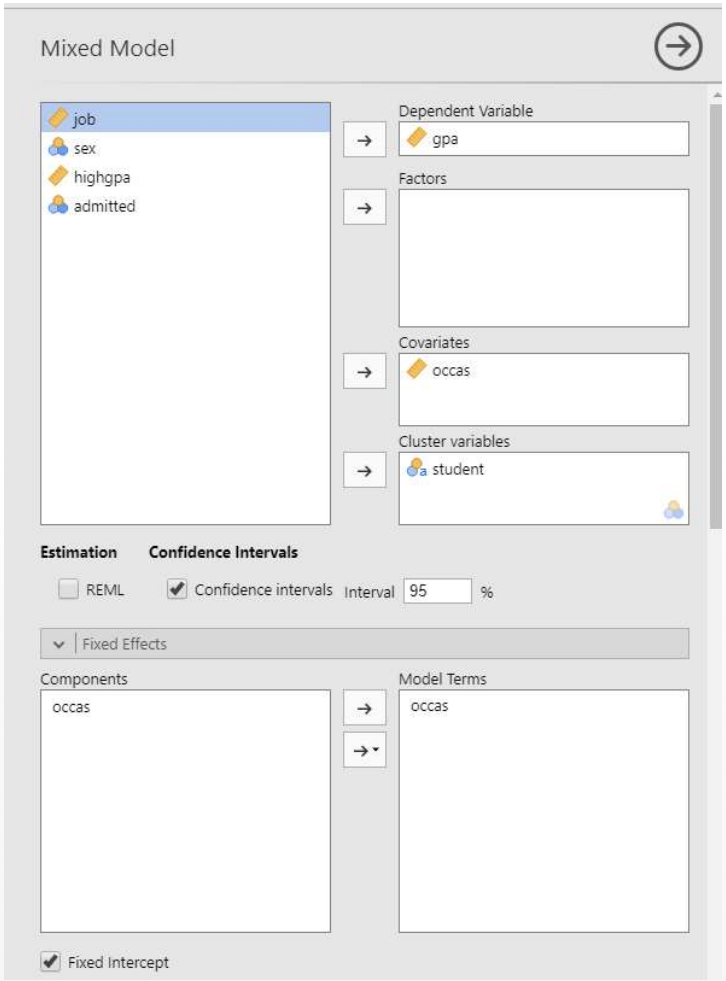
**Uji Rasio Likelihood (LRT) untuk Efek Acak**

- LRT = 100, dengan df = 1 dan p < .001. menunjukkan bahwa menambahkan efek acak siswa secara signifikan akan meningkatkan model fit, dibandingkan model tanpa efek acak.

# Model 2: Waktu di level 1 sebagai prediktor GPA.

$$y_{ti} = \pi_{0i} + \pi_{1i} \cdot \text{occast}_i + \varepsilon_{ti}$$
$$\pi_{0i} = \beta_{00} + \mu_{0i}$$
$$\pi_{1i} = \beta_{10}$$
$$y_{ti} = \beta_{00} + \beta_{10} \cdot \text{occast}_i + \mu_{0i} + \varepsilon_{ti}$$

- Model ini mengasumsikan bahwa semua individu memiliki pengaruh yang sama dari **occast**, tetapi berbeda dalam baseline **depresi**.
- Cocok untuk data longitudinal atau nested di mana kita ingin mengontrol variabilitas antar individu tapi tidak memodelkan perbedaan respons terhadap occast.




**Dependent Variable**

- Variabel outcome yang ingin diprediksi (gpa) oleh model berdasarkan faktor tetap dan acak.

**Factors & Covariates (prediktor)**

- Factors: prediktor kategorikal (menguji pengaruh tetap).
- Covariates: prediktor kontinu (menguji pengaruh tetap).

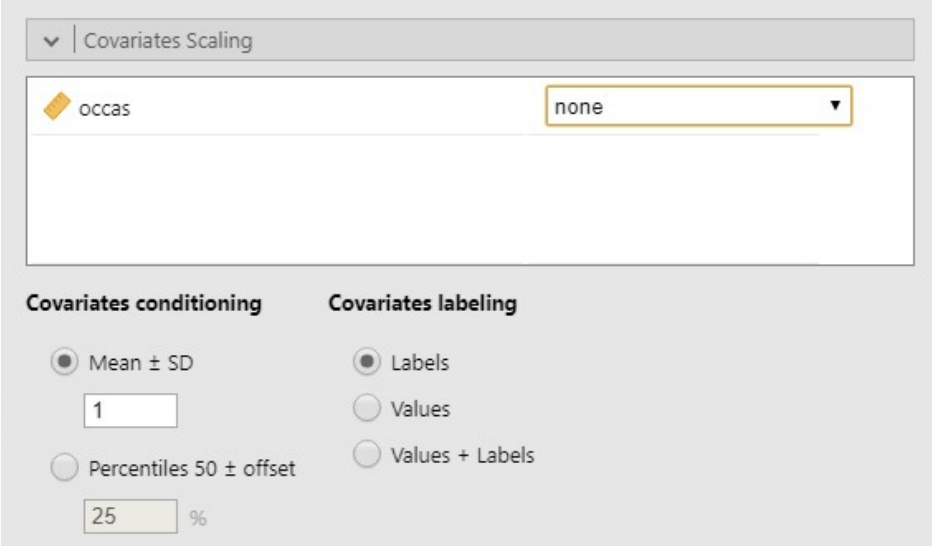
**Cluster Variables (data level)**

- Variabel pengelompokan acak, memodelkan intercept acak antar siswa.

**Fixed Effects & Model Terms**

- Fixed Effects: variabel yang Anda ingin uji secara eksplisit.
- Model Terms: model analisis (dengan atau tanpa interaksi).

# Penskalaan (baseline) untuk Kovariat



## Model Results

Fixed Effect Omnibus tests

| | F | Num df | Den df | p |
|---|---|---|---|---|
| occas | 682 | 1 | 1000 | < .001 |

*Note.* Satterthwaite method for degrees of freedom

Fixed Effects Parameter Estimates

| | | | 95% Confidence Interval | | | | |
|---|---|---|---|---|---|---|---|
| Names | Estimate | SE | Lower | Upper | df | t | p |
| (Intercept) | 2.599 | 0.02165 | 2.5568 | 2.642 | 324 | 120.0 | < .001 |
| occas | 0.106 | 0.00407 | 0.0983 | 0.114 | 1000 | 26.1 | < .001 |

Random Components

| Groups | Name | SD | Variance | ICC |
|---|---|---|---|---|
| student | (Intercept) | 0.252 | 0.0634 | 0.522 |
| Residual | | 0.241 | 0.0580 | |

*Note.* Number of Obs: 1200 , groups: student , 200

Random Effect LRT

| Test | N. par | AIC | LRT | df | p |
|---|---|---|---|---|---|
| (1 \| student) | 3.00 | 881 | 481 | 1.00 | < .001 |

### Fixed Effect Omnibus Test

Secara keseluruhan, occas memberikan kontribusi signifikan terhadap perubahan skor gpa. Menjawab apakah efek tetap dari occas secara umum berbeda dari nol.

### Fixed Effects Parameter Estimates

- Intercept/baseline = 2.599 adalah rata-rata gpa ketika occas = 0.
- Prediksi oleh occas = 0.106, setiap kenaikan satu unit pada occas meningkatkan gpa sebesar 0.106.

### Random Components

- Menunjukkan bahwa baseline gpa berbeda antar siswa.
- ICC = 0.522 → 52.2% varians total berasal dari perbedaan antar siswa, bukan dari fluktuasi dalam siswa.

### Random Effect Likelihood Ratio Test (LRT)

- Menunjukkan bahwa menambahkan efek acak siswa secara signifikan meningkatkan kecocokan model.
- AIC = 881, mengalami penurunan dari sebelumnya (AIC = 1167)

## Simulasi Prediksi

- Prediksi GPA pada semester 2 (penambahan 1 semester)
  - $\beta_{00} + \beta_{10}(1) = 2.599 + .106(1) = 2.705.$
- Prediksi GPA pada semester 3 (penambahan 2 semester)
  - $\beta_{00} + \beta_{10}(2) = 2.599 + .106(2) = 2.811.$
- Prediksi GPA pada semester 3 (penambahan 3 semester)
  - $\beta_{00} + \beta_{10}(2) = 2.599 + .106(3) = 2.908...$

# Model 3 – Job ‘masuk’

$$y_{ti} = \pi_{0i} + \pi_{1i} \cdot occas_{ti} + \pi_{2i} \cdot job + \varepsilon_{ti}$$

$$\pi_{0i} = \beta_{00} + \mu_{0i}$$ dibuat random (bervariasi)

$$\pi_{1i} = \beta_{10}$$

$$\pi_{2i} = \beta_{20}$$

$$y_{ti} = \beta_{00} + \beta_{10} \cdot occas_{ti} + \beta_{20} \cdot job + \mu_{0i} + \varepsilon_{ti}$$

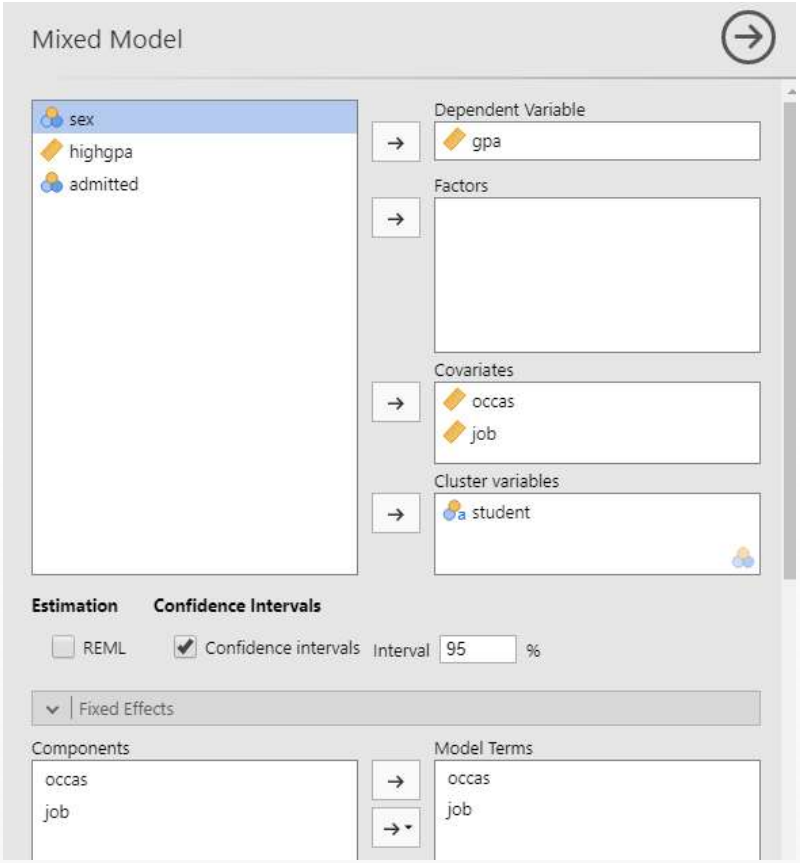
Model di atas merupakan bentuk hierarkis dua tingkat yang memprediksi skor GPA berdasarkan kombinasi efek tetap dan acak.

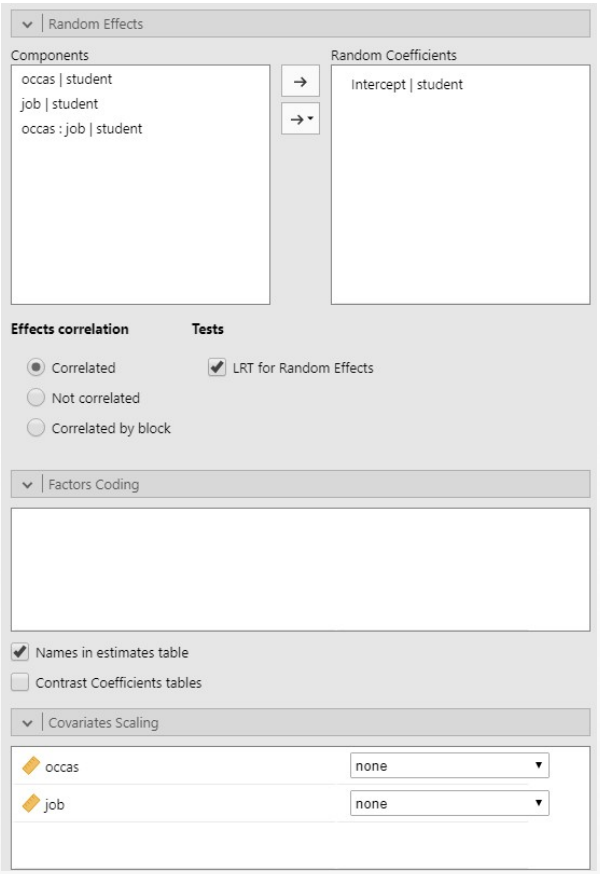
Pada level pertama, skor individu pada waktu ke-t dipengaruhi oleh intercept khusus individu (pi-0i), efek dari variabel occas dan efek dari job serta error residual

Di level kedua, hanya intercept (pi-0i) yang diperlakukan sebagai acak, dengan rata-rata populasi (Beta-00) dan deviasi individu (mu-0i), sementara prediksi oleh occas dan job diasumsikan tetap di seluruh individu.

Model gabungan menyatukan semua komponen tersebut menjadi satu persamaan yang menunjukkan bahwa skor akhir dipengaruhi oleh rata-rata populasi, efek tetap dari occas dan job, serta variasi acak antar individu dan fluktuasi dalam individu.

# Menu Analisis



# Keluaran Analisis

Fixed Effect Omnibus tests

| | F | Num df | Den df | p |
|---|---|---|---|---|
| occas | 659.7 | 1 | 995 | < .001 |
| job | 89.6 | 1 | 1092 | < .001 |

*Note.* Satterthwaite method for degrees of freedom

Fixed Effects Parameter Estimates

| | | | 95% Confidence Interval | | | | |
|---|---|---|---|---|---|---|---|
| Names | Estimate | SE | Lower | Upper | df | t | p |
| (Intercept) | 2.970 | 0.04407 | 2.8839 | 3.057 | 1191 | 67.40 | < .001 |
| occas | 0.102 | 0.00399 | 0.0946 | 0.110 | 995 | 25.68 | < .001 |
| job | −0.171 | 0.01811 | −0.2070 | −0.136 | 1092 | −9.47 | < .001 |

- Intersep = 2.97 adalah IPK yang diharapkan untuk mahasiswa di semester 1.
- Prediksi occasion (signifikan meningkatkan), pada setiap semester GPA diprediksi meningkat sebesar 0.102.
- Prediksi job (signifikan menurunkan), menunjukkan bahwa untuk setiap jam tambahan yang dihabiskan untuk bekerja selama satu semester menurunkan GPA sebesar 0.171.

# Keluaran Analisis

Random Components

| Groups | Name | SD | Variance | ICC |
|---|---|---|---|---|
| student | (Intercept) | 0.229 | 0.0524 | 0.487 |
| Residual | | 0.235 | 0.0551 | |

*Note.* Number of Obs: 1200 , groups: student , 200

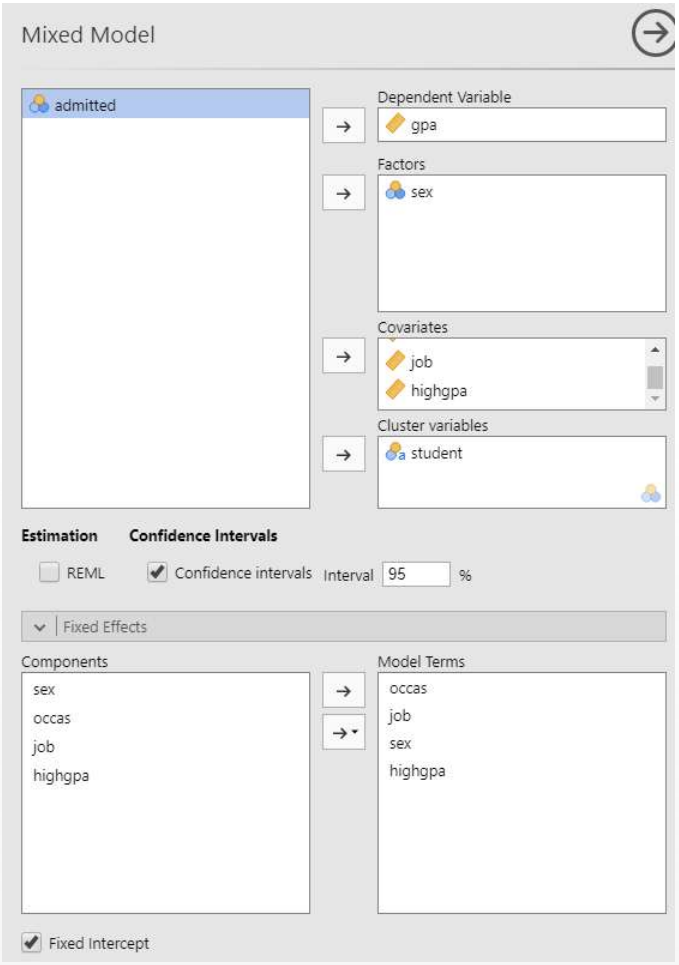
Random Effect LRT

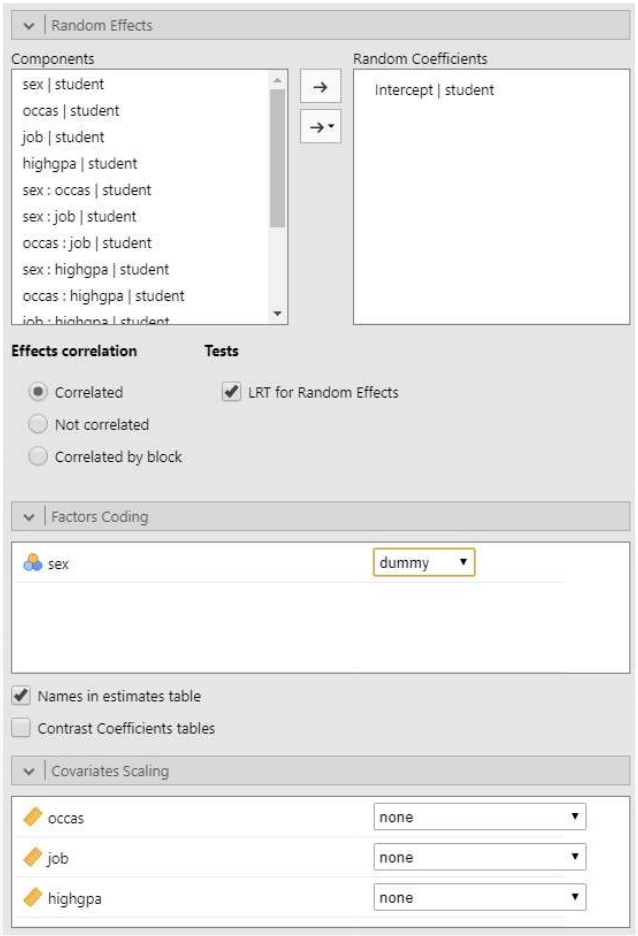
| Test | N. par | AIC | LRT | df | p |
|---|---|---|---|---|---|
| (1 \| student) | 4.00 | 699 | 383 | 1.00 | < .001 |

- Model ini berhasil menangkap struktur hierarkis data, dengan variabilitas antar siswa yang signifikan. Efek acak siswa terbukti penting secara statistik dan ICC yang tinggi (0.487) menunjukkan bahwa hampir separuh varians berasal dari perbedaan antar individu.
- Model ini (AIC = 699) lebih tepat dibanding dengan sebelumnya (AIC = 881)

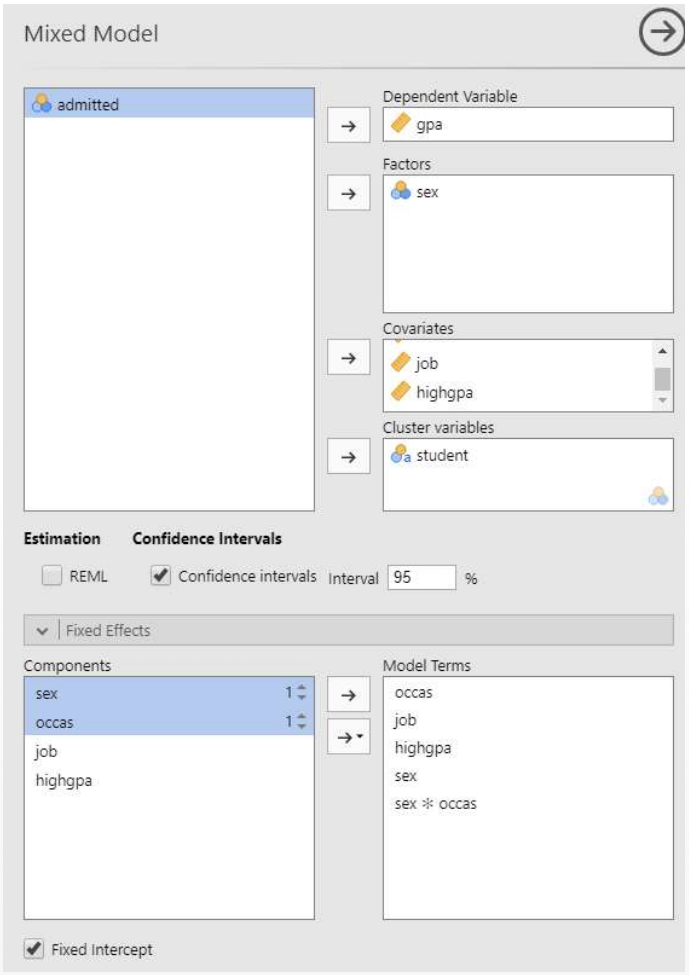
dan cerita berlanjut .... hingga mendapatkan model yang optimal dalam menjelaskan GPA

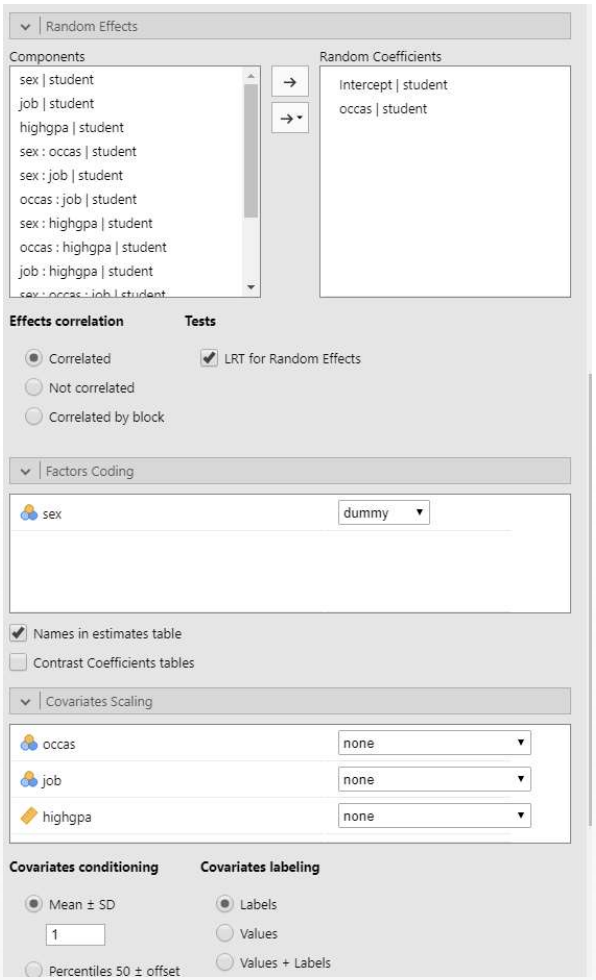
# Model 4: Jenis Kelamin ‘masuk’



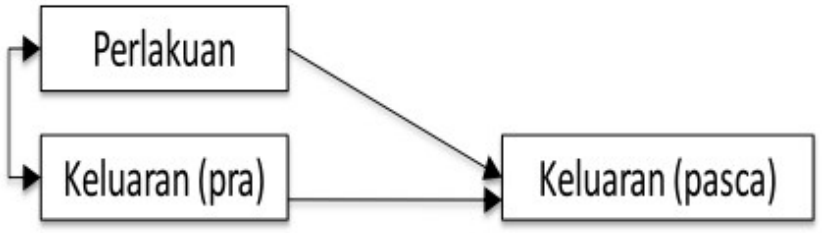
# Model 5: Ada ‘interaksi’



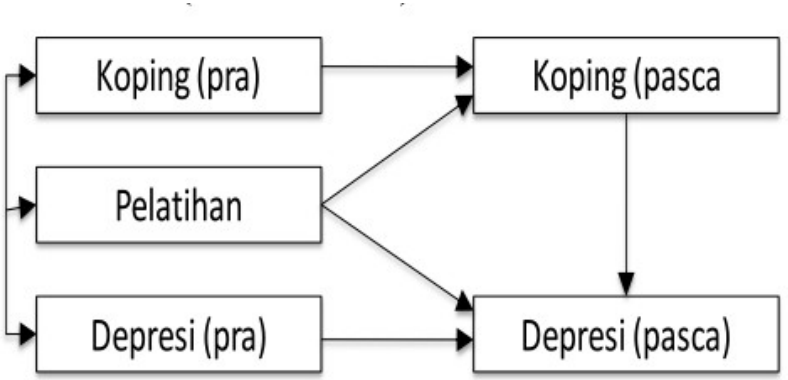



# Kasus Analisis:
# Riset Eksperimen

# Model Analisis Data Eksperimen Melalui Analisis Regresi



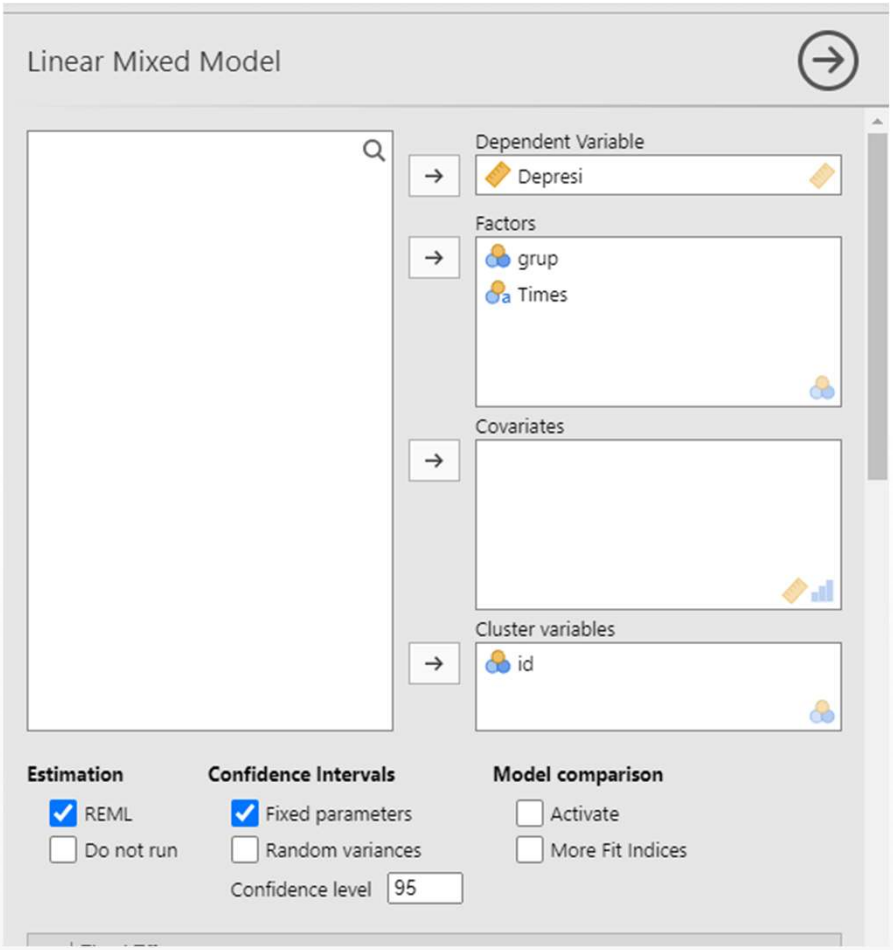

**Gambar 1. Model Analisis Kovarians**




**Gambar 4. Desain Penelitian**

Using a pretest as a covariate in experimental design involves the Analysis of Covariance (ANCOVA), a statistical technique that controls for pre-existing differences between groups on the dependent variable at the posttest. This noise-reducing design adjusts posttest scores for pretest variability, effectively "subtracting out" the pretest effect to better isolate the impact of the treatment. The pretest is an ideal covariate because it is typically the most highly correlated with the posttest, allowing for greater precision in analyzing the true treatment effect.

# Model Data 1




## Model Results

Model Fit

| Type | $R^2$ | df | LRT $X^2$ | p |
|---|---|---|---|---|
| Conditional | 0.720 | 6 | 175.934 | < .001 |
| Marginal | 0.678 | 5 | 168.404 | < .001 |

[4]

Fixed Effects Omnibus Tests

| | F | df | df (res) | p |
|---|---|---|---|---|
| grup | 129.9 | 1 | 48.0 | < .001 |
| Times | 25.7 | 2 | 96.0 | < .001 |
| grup ✻ Times | 60.6 | 2 | 96.0 | < .001 |

Parameter Estimates (Fixed coefficients)

| | | | | 95% Confidence Intervals | | | | |
|---|---|---|---|---|---|---|---|---|
| Names | Effect | Estimate | SE | Lower | Upper | df | t | p |
| (Intercept) | (Intercept) | 23.51 | 0.199 | 23.11 | 23.900 | 48.0 | 118.19 | < .001 |
| grup1 | 1 - 0 | −4.53 | 0.398 | −5.32 | −3.747 | 48.0 | −11.40 | < .001 |
| Times1 | dep2 - dep1 | −2.90 | 0.404 | −3.70 | −2.101 | 96.0 | −7.17 | < .001 |
| Times2 | dep3 - dep1 | −1.40 | 0.404 | −2.20 | −0.601 | 96.0 | −3.46 | < .001 |
| grup1 ✻ Times1 | (1 - 0) ✻ (dep2 - dep1) | −7.48 | 0.809 | −9.08 | −5.881 | 96.0 | −9.25 | < .001 |
| grup1 ✻ Times2 | (1 - 0) ✻ (dep3 - dep1) | −7.92 | 0.809 | −9.52 | −6.321 | 96.0 | −9.79 | < .001 |

[5]

Random Components

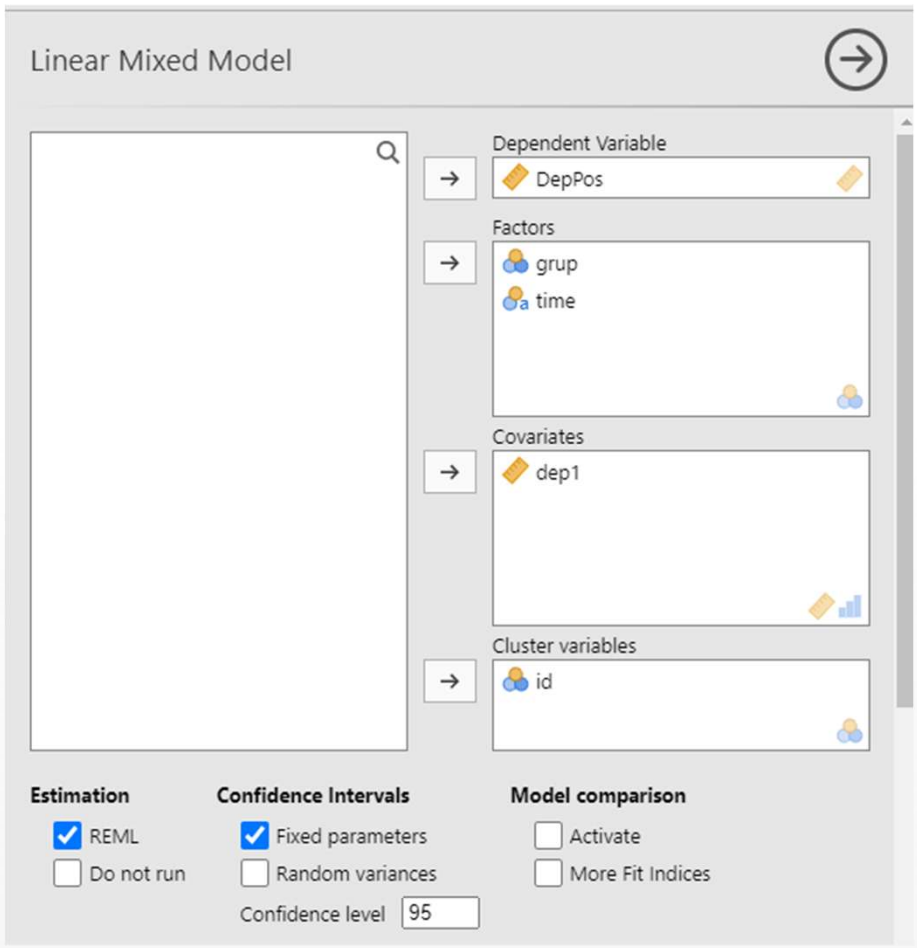
| Groups | Name | Variance | SD | ICC |
|---|---|---|---|---|
| id | (Intercept) | 0.616 | 0.785 | 0.131 |
| Residual | | 4.087 | 2.022 | |

*Note.* Number of Obs: 150 , Number of groups: id 50

Random Effect LRT

| Test | N. par | AIC | LRT | df | p |
|---|---|---|---|---|---|
| (1 \| id) | 7.00 | 665 | 2.31 | 1.00 | 0.129 |

# Model Data 2




Fixed Effects Omnibus Tests

| | F | df | df (res) | p |
|---|---|---|---|---|
| dep1 | 2.190 | 1 | 46.8 | 0.146 |
| grup | 233.163 | 1 | 46.4 | < .001 |
| time | 11.737 | 1 | 48.0 | 0.001 |
| grup ✻ time | 0.252 | 1 | 48.0 | 0.618 |

Parameter Estimates (Fixed coefficients)

| | | | | 95% Confidence Intervals | | | | |
|---|---|---|---|---|---|---|---|---|
| Names | Effect | Estimate | SE | Lower | Upper | df | t | p |
| (Intercept) | (Intercept) | 22.790 | 0.233 | 22.3269 | 23.253 | 46.4 | 97.750 | < .001 |
| dep1 | dep1 | 0.183 | 0.124 | −0.0628 | 0.429 | 46.8 | 1.480 | 0.146 |
| grup1 | 1 - 0 | −7.210 | 0.472 | −8.1479 | −6.272 | 46.4 | −15.270 | < .001 |
| time1 | dep3 - dep2 | 1.500 | 0.438 | 0.6303 | 2.370 | 48.0 | 3.426 | 0.001 |
| grup1 ✻ time1 | (1 - 0) ✻ (dep3 - dep2) | −0.440 | 0.876 | −2.1794 | 1.299 | 48.0 | −0.502 | 0.618 |

[5]

Random Components

| Groups | Name | Variance | SD | ICC |
|---|---|---|---|---|
| id | grup0 | 0.00994 | 0.0997 | |
| | grup1 | 0.63322 | 0.7958 | |
| Residual | | 4.79250 | 2.1892 | |

*Note.* Number of Obs: 100 , Number of groups: id 50

Random Parameters correlations

| Groups | param1 | param2 | Cov. | Corr. |
|---|---|---|---|---|
| id | grup0 | grup1 | −0.0160 | −0.202 |

Random Effect LRT

| Test | N. par | AIC | LRT | df | p |
|---|---|---|---|---|---|
| grup in (0 + grup \| id) | 7 | 457 | 0.310 | 2.00 | 0.856 |

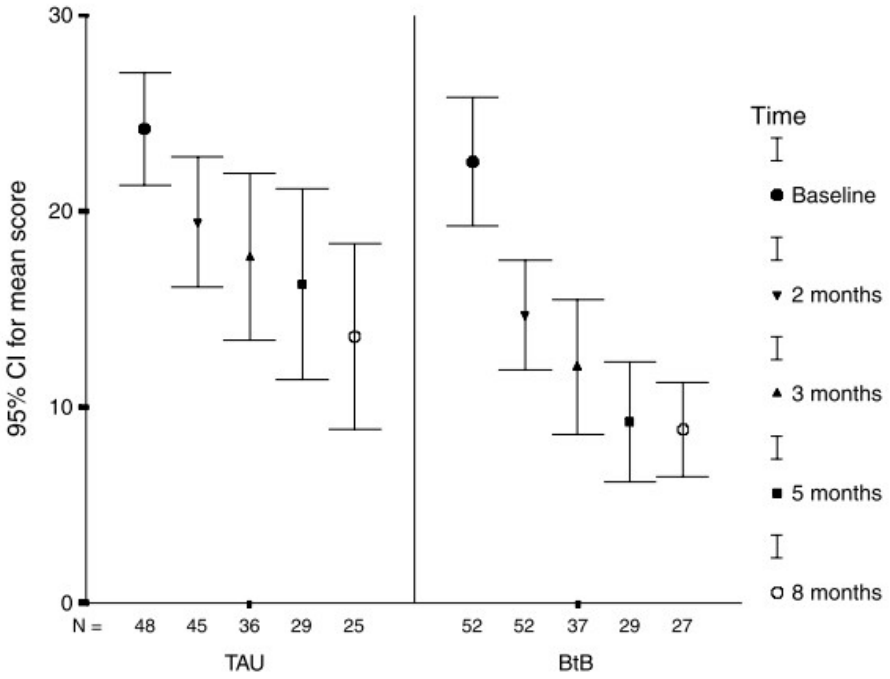
# Deskripsi Data

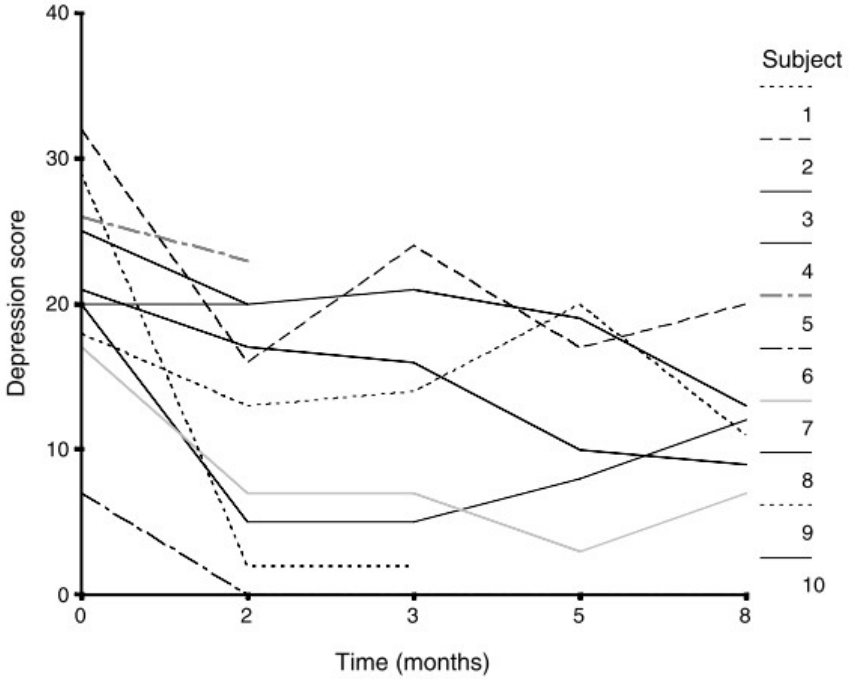
- Sebuah studi yang membandingkan dua program pengobatan untuk depresi: TAU (Treatment As Usual) dan BtB (kemungkinan merupakan program intervensi khusus), pada 100 pasien, (TAU = 48 dan BtB = 52).
- Pengukuran dilakukan depresi secara berulang (5x). Sejumlah besar nilai yang hilang akibat pasien keluar dari studi (diberi kode 999).
- Ada variabel pengaruh durasi sakit, duration = 1 (6 bulan) atau duration = 0 (kurang dari 6 bulan).
- Pertanyaan penelitian utama adalah apakah program BtB lebih efektif dibandingkan TAU dalam mengobati depresi.

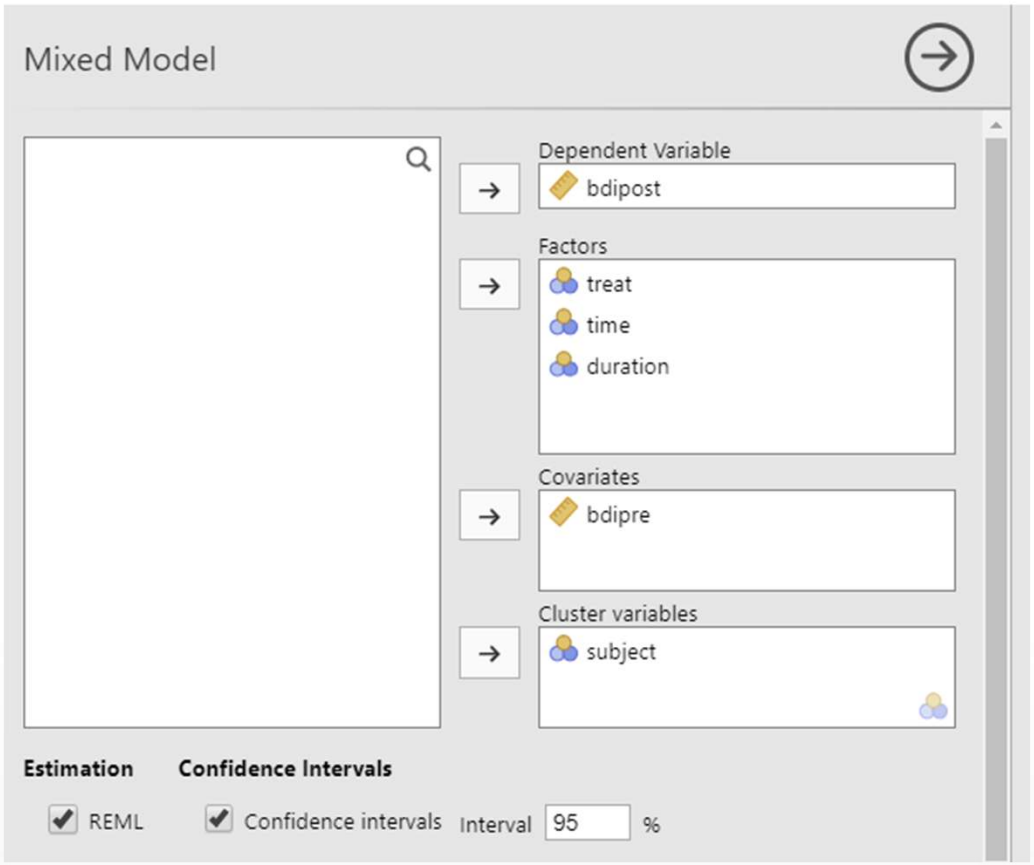
**Table 8.1 A Subset of the Data from the Original BtB Trial**

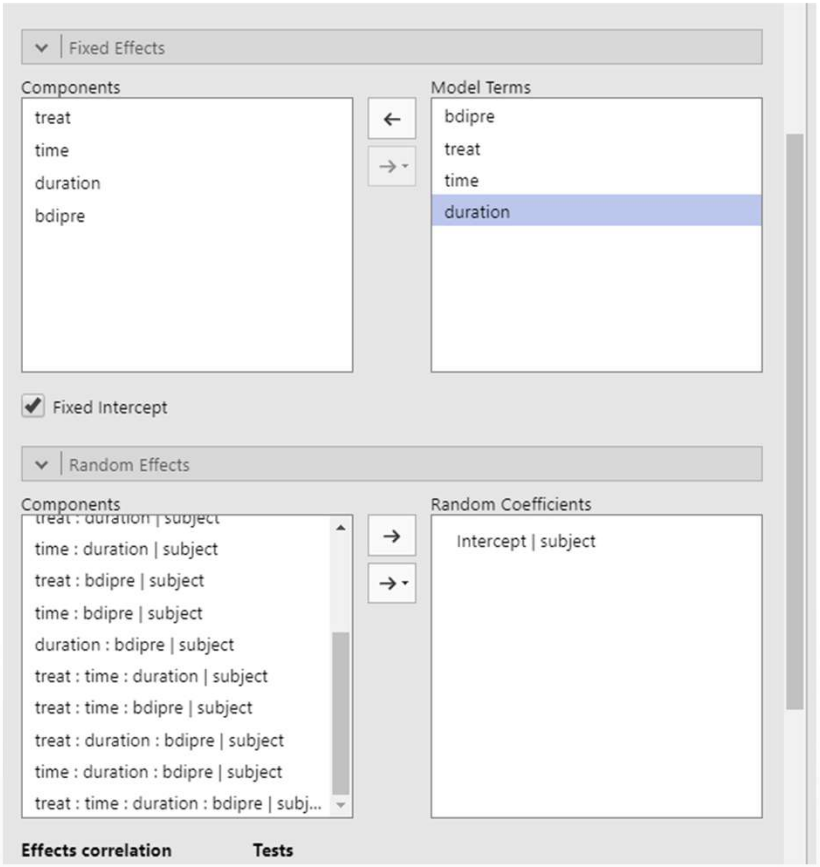
| | | | Depression Score | | | | |
|---|---|---|---|---|---|---|---|
| *Subject* | *Duration*[a] | *Treatment*[b] | *Baseline* | *2 Months* | *3 Months* | *5 Months* | *8 Months* |
| 1 | 1 | 0 | 29 | 2 | 2 | 999[c] | 999 |
| 2 | 1 | 1 | 32 | 16 | 24 | 17 | 20 |
| 3 | 0 | 0 | 25 | 20 | 999 | 999 | 999 |
| 4 | 1 | 1 | 21 | 17 | 16 | 10 | 9 |
| 5 | 1 | 1 | 26 | 23 | 999 | 999 | 999 |
| 6 | 0 | 1 | 7 | 0 | 0 | 0 | 0 |
| 7 | 0 | 0 | 17 | 7 | 7 | 3 | 7 |
| 8 | 1 | 0 | 20 | 20 | 21 | 19 | 13 |
| 9 | 0 | 1 | 18 | 13 | 14 | 20 | 11 |
| 10 | 1 | 1 | 20 | 5 | 5 | 8 | 12 |
| 11 | 1 | 0 | 30 | 32 | 24 | 12 | 2 |

# Perbandingan Plot

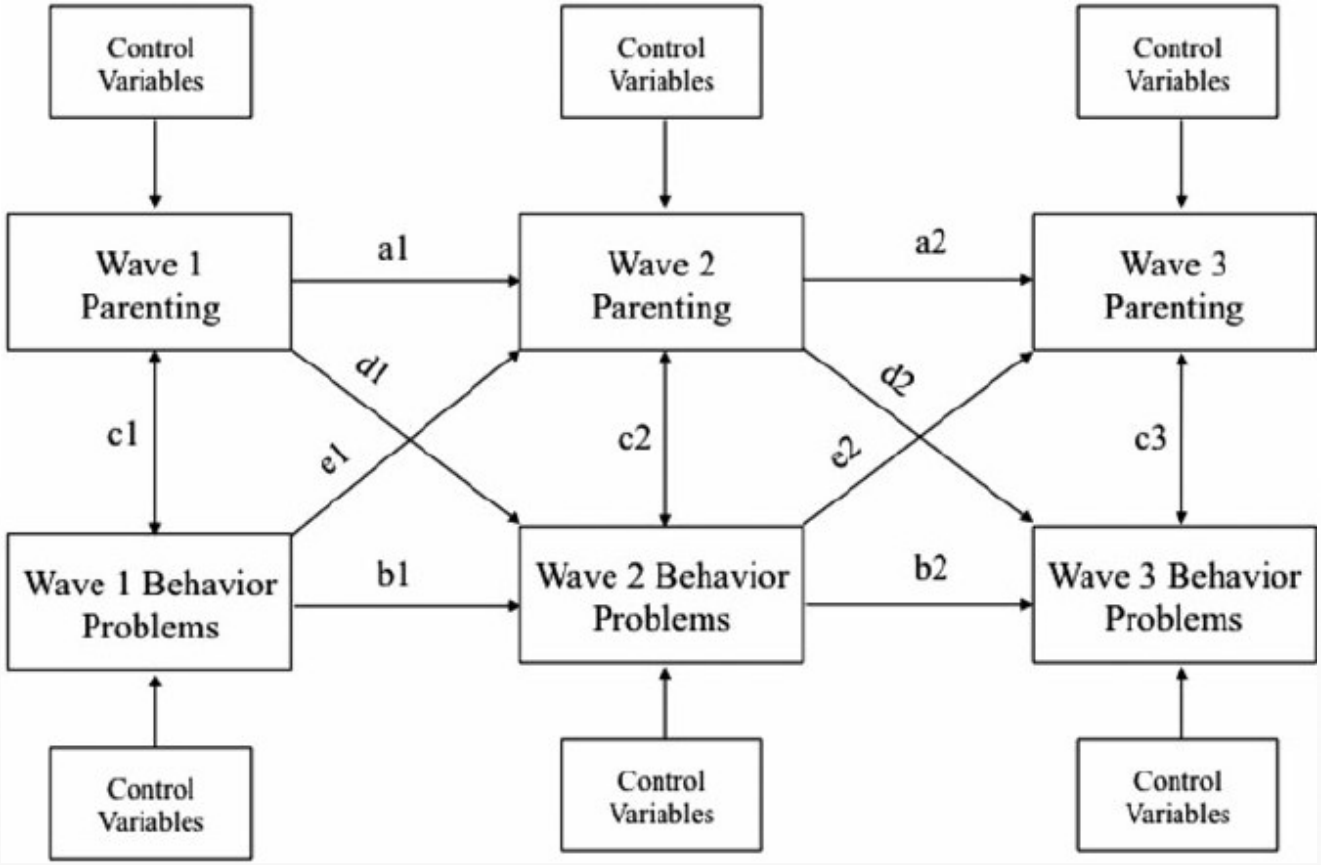


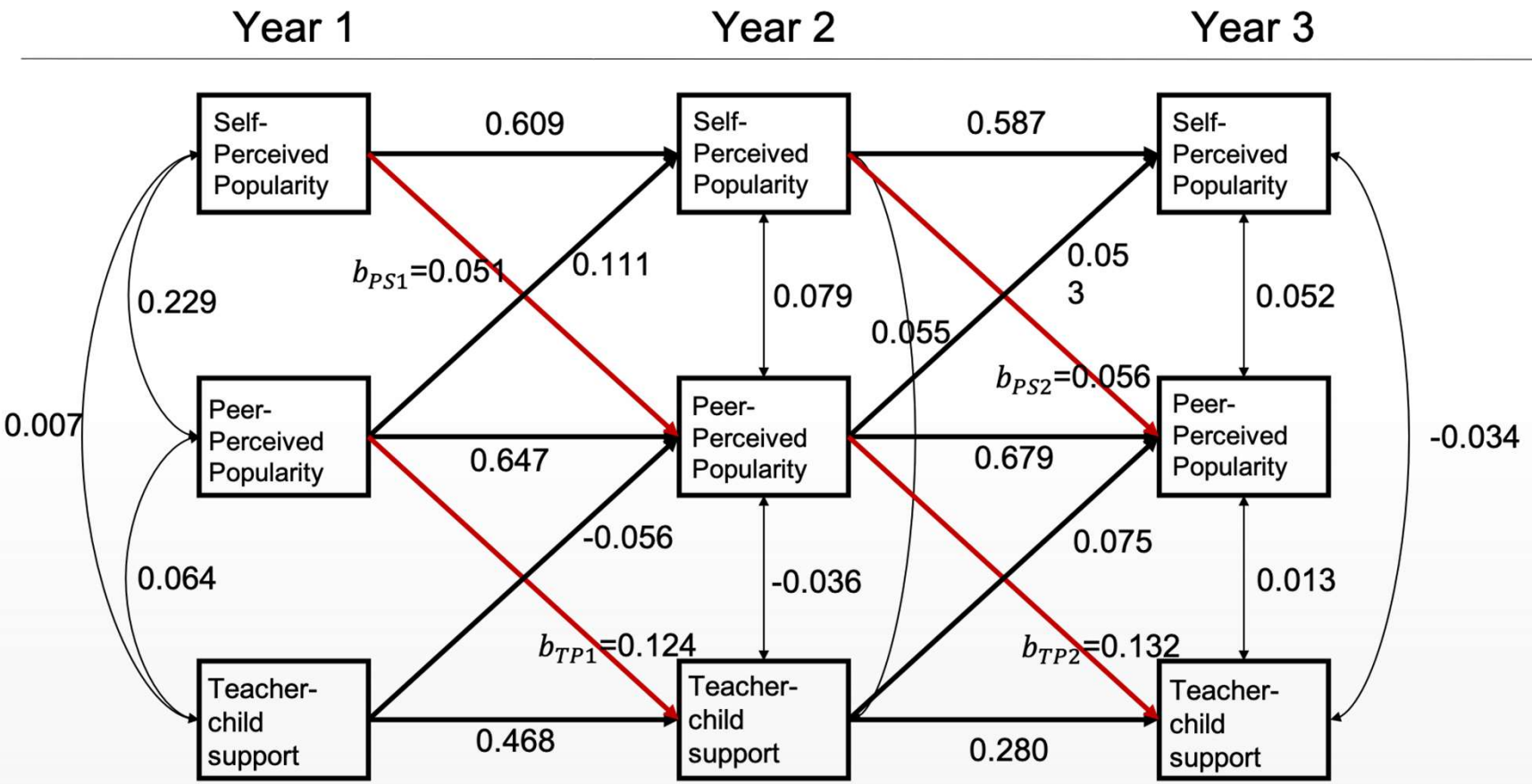

Mixed Model
Dependent Variable
bdipost
Factors
treat
time
duration
Covariates
bdipre
Cluster variables
subject
Estimation
Confidence Intervals
REML
Confidence intervals
Interval
95
%


Fixed Effects
Components
treat
time
duration
bdipre
Model Terms
bdipre
treat
time
duration
Fixed Intercept
Random Effects
Components
time : duration | subject
treat : bdipre | subject
time : bdipre | subject
duration : bdipre | subject
treat : time : duration | subject
treat : time : bdipre | subject
treat : duration : bdipre | subject
time : duration : bdipre | subject
treat : time : duration : bdipre | subj...
Random Coefficients
Intercept | subject
Effects correlation
Tests

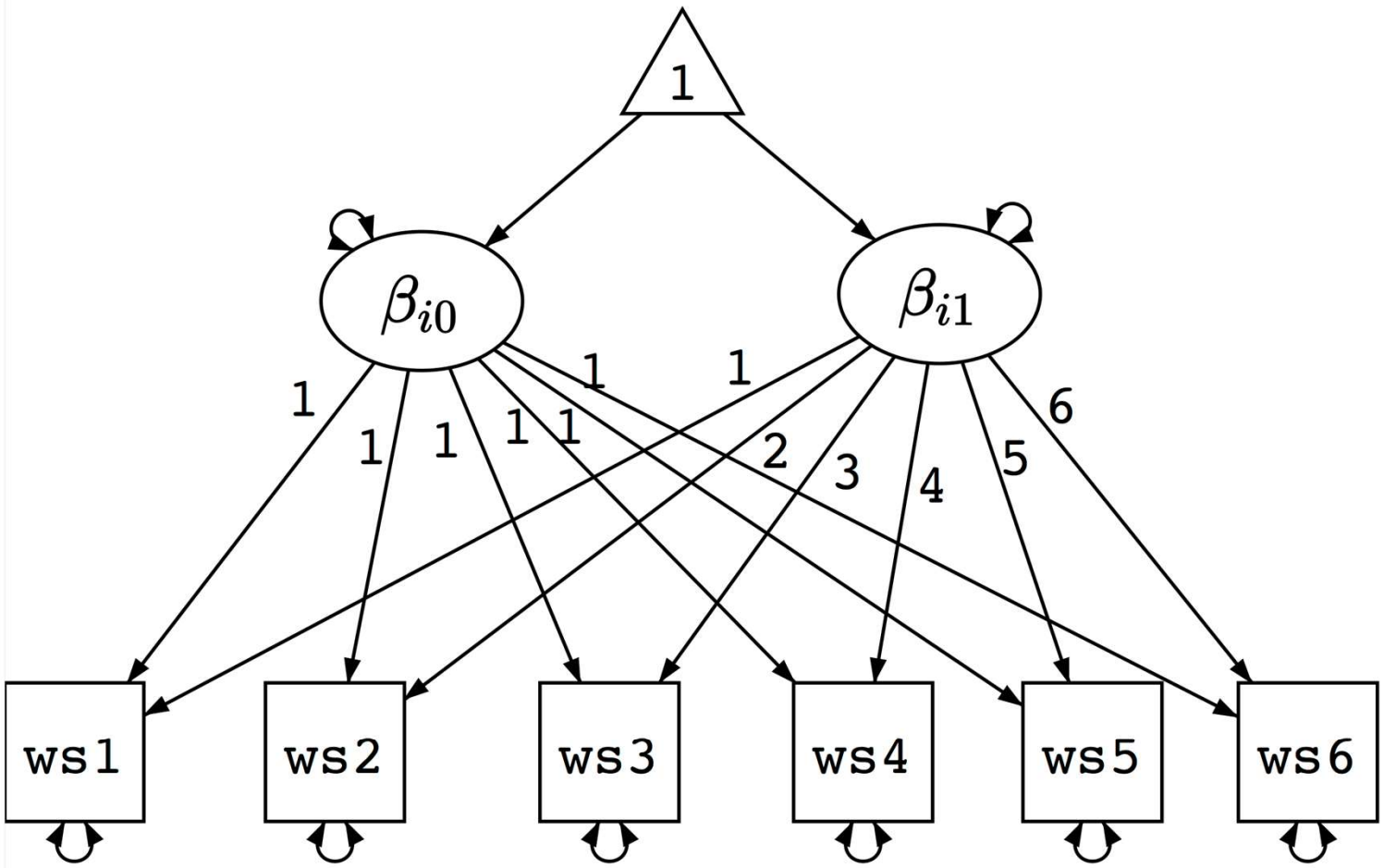
# Cross lagged panel model

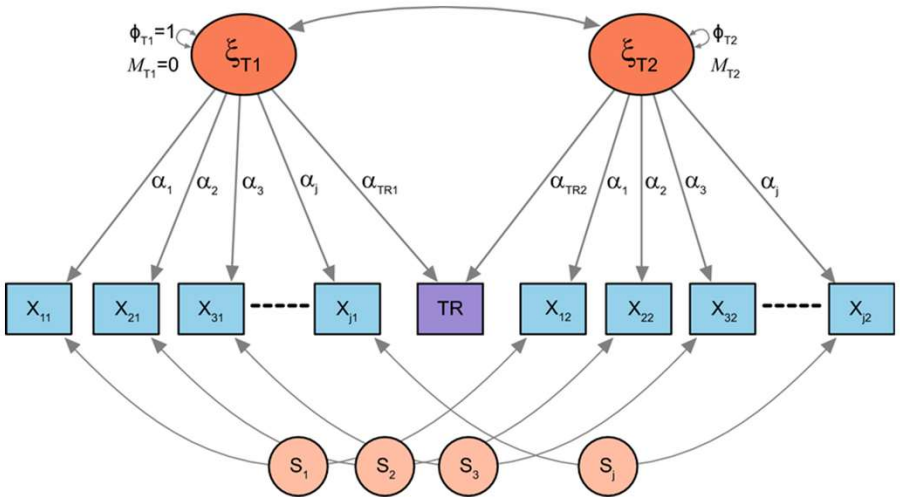


# Cross lagged panel model



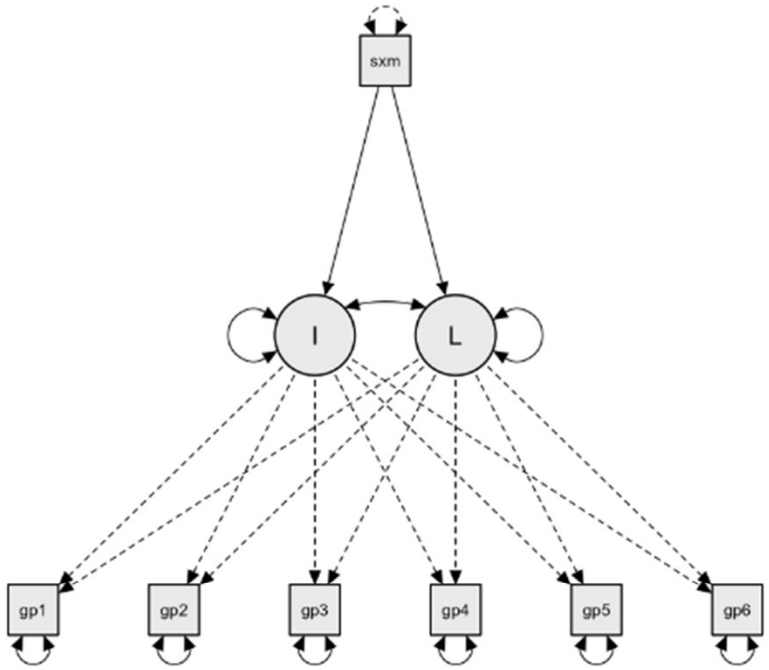
# Kasus Analisis:
# Latent Growth Desain #1


1
$\beta_{i0}$
$\beta_{i1}$
1
1
1
1
1
1
1
2
3
4
5
6
ws1
ws2
ws3
ws4
ws5
ws6




Gambar ini menggambarkan sebuah **model SEM multilevel atau multigrup** yang menguji bagaimana **dua konstruk laten** (ξT1 dan ξT2) diukur melalui indikator, dipengaruhi oleh perlakuan (TR), dan berdampak pada sejumlah outcome (Si). Model ini cocok untuk studi eksperimental atau evaluatif yang melibatkan **mediasi, pengaruh tidak langsung, dan struktur pengukuran yang kompleks**.

Model plot ▼




$$
\begin{aligned}
GPA_{i0} &= Intercept_i + 0 * Slope_i + e_{i0} \\
GPA_{i1} &= Intercept_i + 1 * Slope_i + e_{i1} \\
GPA_{i2} &= Intercept_i + 2 * Slope_i + e_{i2} \\
GPA_{i3} &= Intercept_i + 3 * Slope_i + e_{i3} \\
GPA_{i4} &= Intercept_i + 4 * Slope_i + e_{i4} \\
GPA_{i5} &= Intercept_i + 5 * Slope_i + e_{i5}
\end{aligned}
$$

**Parameter estimates** ▼

*Latent curve*

| Component | Parameter | Estimate | Std. error | z-value | p | 95% Confidence Interval Lower | Upper |
|---|---|---|---|---|---|---|---|
| Intercept | Mean | 2.639 | 0.025 | 106.036 | < .001 | 2.591 | 2.688 |
| | Variance | 0.033 | 0.007 | 4.795 | < .001 | 0.019 | 0.046 |
| Linear slope | Mean | 0.119 | 0.007 | 16.670 | < .001 | 0.105 | 0.133 |
| | Variance | 0.003 | 0.001 | 5.509 | < .001 | 0.002 | 0.004 |

*Latent covariances* ▼

| | | | Estimate | Std. error | z-value | p | 95% Confidence Interval Lower | Upper |
|---|---|---|---|---|---|---|---|---|
| Intercept | ↔ | Linear slope | 0.002 | 0.001 | 1.292 | .196 | −0.001 | 0.005 |

*Regressions*

| Component | Predictor | Estimate | Std. error | z-value | p | 95% Confidence Interval Lower | Upper |
|---|---|---|---|---|---|---|---|
| Intercept | sexmale | −0.087 | 0.036 | −2.415 | .016 | −0.158 | −0.016 |
| Linear slope | sexmale | −0.026 | 0.010 | −2.484 | .013 | −0.046 | −0.005 |

*Residual variances*

| Variable | Estimate | Std. error | z-value | p | 95% Confidence Interval Lower | Upper |
|---|---|---|---|---|---|---|
| gpa1 | 0.079 | 0.010 | 8.136 | < .001 | 0.060 | 0.099 |
| gpa2 | 0.071 | 0.008 | 8.804 | < .001 | 0.055 | 0.086 |
| gpa3 | 0.054 | 0.006 | 9.045 | < .001 | 0.042 | 0.066 |
| gpa4 | 0.029 | 0.003 | 8.528 | < .001 | 0.022 | 0.035 |
| gpa5 | 0.015 | 0.002 | 5.999 | < .001 | 0.010 | 0.019 |
| gpa6 | 0.016 | 0.003 | 4.659 | < .001 | 0.009 | 0.023 |

1. **Kovariansi Laten: Intercept ↔ Slope**
Estimasi = 0.212, p = 0.196 → tidak signifikan.
Artinya: tidak ada hubungan yang cukup kuat antara level awal (intercept) dan laju perubahan (slope) skor GPA dari waktu ke waktu. Individu dengan skor awal tinggi belum tentu mengalami perubahan yang lebih cepat atau lambat.

2. **Regresi Intercept dan Slope terhadap Jenis Kelamin (sexmale)**

- Intercept ~ sexmale: Estimasi = -0.087, p = 0.016 → signifikan. Artinya: laki-laki cenderung memiliki skor GPA awal yang lebih rendah dibanding perempuan, dengan selisih rata-rata 0.087 poin.
- Slope ~ sexmale: Estimasi = -0.206, p < .001 → sangat signifikan. Artinya: laki-laki mengalami penurunan GPA yang lebih tajam dari waktu ke waktu dibanding perempuan, dengan rata-rata penurunan 0.206 poin per unit waktu.

**Parameter estimates** ▼

*Latent curve*

| Component | Parameter | Estimate | Std. error | z-value | p | 95% Confidence Interval Lower | Upper |
|---|---|---|---|---|---|---|---|
| Intercept | Mean | 2.639 | 0.025 | 106.036 | < .001 | 2.591 | 2.688 |
| | Variance | 0.033 | 0.007 | 4.795 | < .001 | 0.019 | 0.046 |
| Linear slope | Mean | 0.119 | 0.007 | 16.670 | < .001 | 0.105 | 0.133 |
| | Variance | 0.003 | 0.001 | 5.509 | < .001 | 0.002 | 0.004 |

*Latent covariances* ▼

| | | | Estimate | Std. error | z-value | p | 95% Confidence Interval Lower | Upper |
|---|---|---|---|---|---|---|---|---|
| Intercept | ↔ | Linear slope | 0.002 | 0.001 | 1.292 | .196 | −0.001 | 0.005 |

*Regressions*

| Component | Predictor | Estimate | Std. error | z-value | p | 95% Confidence Interval Lower | Upper |
|---|---|---|---|---|---|---|---|
| Intercept | sexmale | −0.087 | 0.036 | −2.415 | .016 | −0.158 | −0.016 |
| Linear slope | sexmale | −0.026 | 0.010 | −2.484 | .013 | −0.046 | −0.005 |

*Residual variances*

| Variable | Estimate | Std. error | z-value | p | 95% Confidence Interval Lower | Upper |
|---|---|---|---|---|---|---|
| gpa1 | 0.079 | 0.010 | 8.136 | < .001 | 0.060 | 0.099 |
| gpa2 | 0.071 | 0.008 | 8.804 | < .001 | 0.055 | 0.086 |
| gpa3 | 0.054 | 0.006 | 9.045 | < .001 | 0.042 | 0.066 |
| gpa4 | 0.029 | 0.003 | 8.528 | < .001 | 0.022 | 0.035 |
| gpa5 | 0.015 | 0.002 | 5.999 | < .001 | 0.010 | 0.019 |
| gpa6 | 0.016 | 0.003 | 4.659 | < .001 | 0.009 | 0.023 |

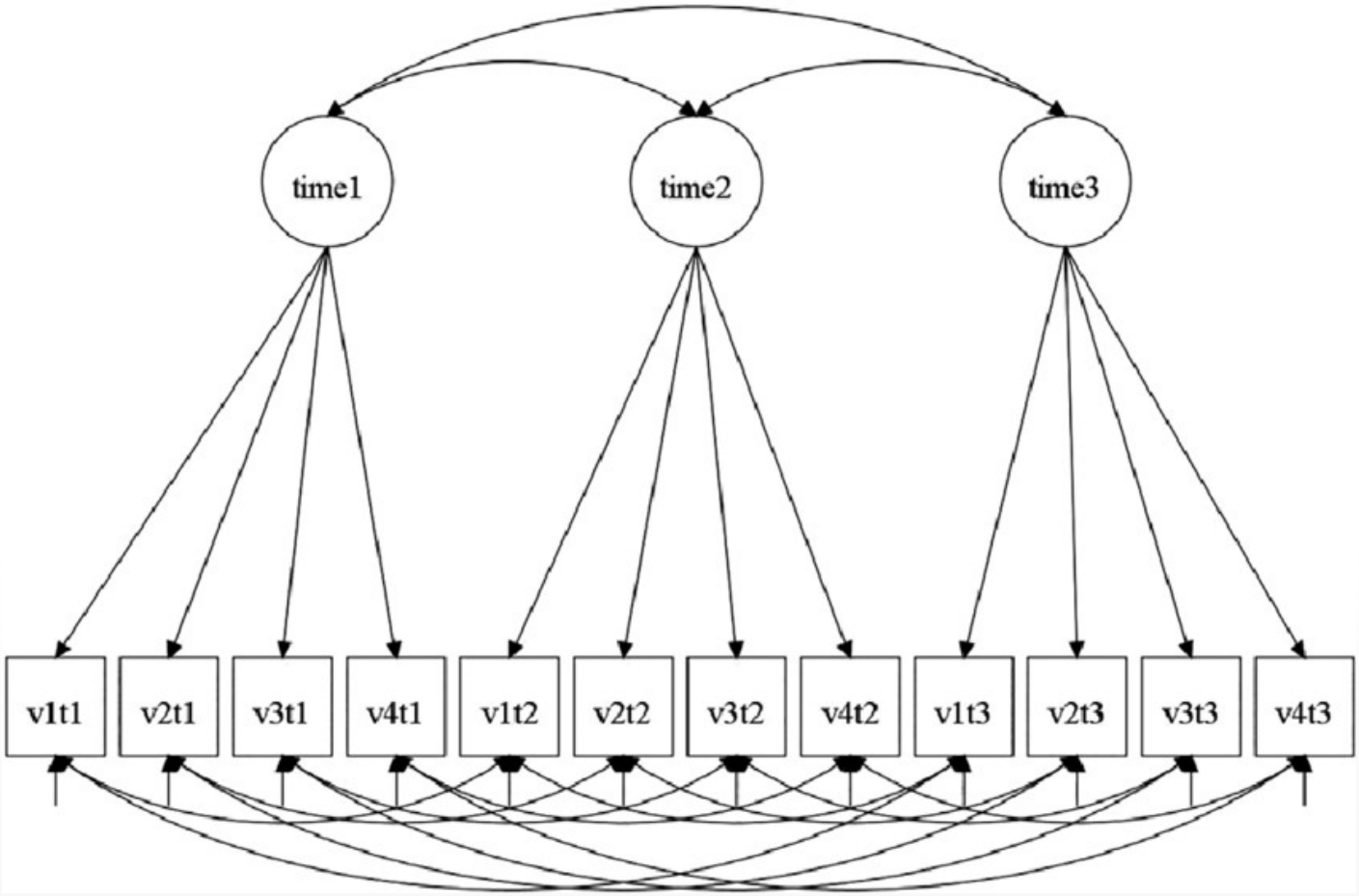
## 3. Varians Residual GPA (gpa1–gpa6)

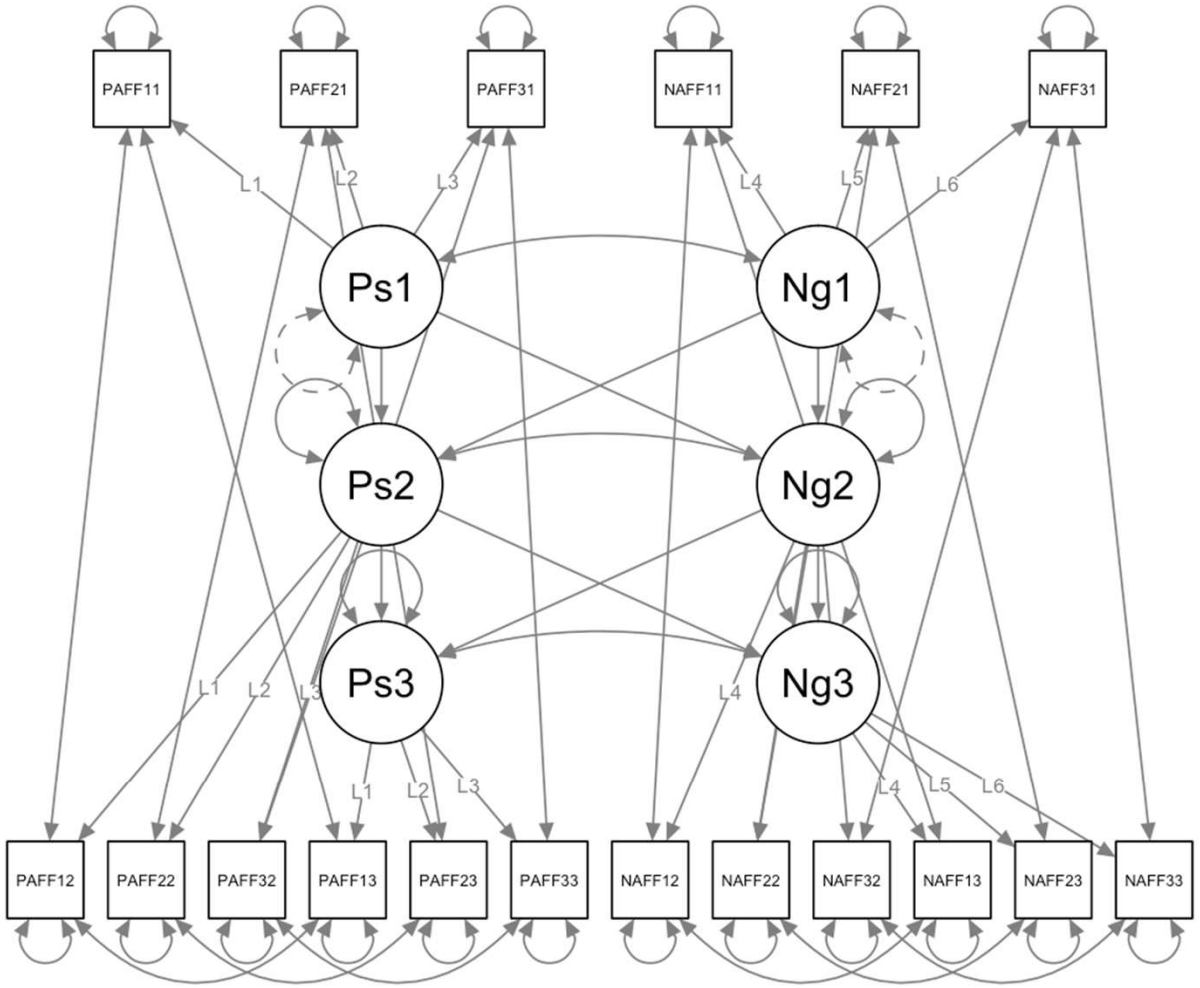
- Semua residual signifikan ($p < .001$), menunjukkan bahwa masih ada variabilitas yang tidak dijelaskan oleh model pada setiap titik waktu.
- Varians tertinggi terjadi pada gpa3 dan gpa2, sedangkan varians terendah pada gpa4 dan gpa6.
- Menunjukkan bahwa stabilitas atau fluktuasi GPA berubah sepanjang waktu, mungkin karena pengaruh eksternal atau efektivitas intervensi.

## 4. Efek Acak antar Subjek

- SD Intercept antar subjek = 7.225, ICC = 0.64 → menunjukkan bahwa 64% varians GPA berasal dari perbedaan antar individu, bukan dari fluktuasi dalam individu.
- Mendukung penggunaan model multilevel karena variabilitas antar siswa cukup besar.

# Kasus Analisis:
# Latent Growth Desain #2


time1
time2
time3
v1t1
v2t1
v3t1
v4t1
v1t2
v2t2
v3t2
v4t2
v1t3
v2t3
v3t3
v4t3


PAFF11
PAFF21
PAFF31
NAFF11
NAFF21
NAFF31
L1
L2
L3
L4
L5
L6
Ps1
Ng1
Ps2
Ng2
Ps3
Ng3
L1
L2
L3
L4
L1
L2
L3
L4
L5
L6
PAFF12
PAFF22
PAFF32
PAFF13
PAFF23
PAFF33
NAFF12
NAFF22
NAFF32
NAFF13
NAFF23
NAFF33